1984

A Comparison of the Trainability of Former Athletes and Sedentary Men, 30-39 Years Old

Donna Jane Riddell

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Faculty of Graduate Studies

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January 28, 1985
(date)

M.A.
(degree)

Physical Education
(department of student)

A COMPARISON OF THE TRAINABILITY OF FORMER ATHLETES AND SEDENTARY MEN, 30-39 YEARS OLD

by

Donna Jane Riddell

Faculty of Physical Education

2

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Faculty of Graduate Studies
The University of Western Ontario
London, Ontario
September, 1984

THE UNIVERSITY OF WESTERN ONTARIO-FACULTY OF GRADUATE STUDIES

CERTIFICATE OF EXAMINATION

Chief Advisor

E G Noble

Advisory Committee

Craig R Hall

Examining Board

Richard H Weick

Craig R Hall

The thesis by

Donna Jane Riddell

entitled

A Comparison of the Trainability of Former Athletes and Sedentary Men, 30-39 Years old

is accepted in partial
fulfillment of the requirements of
the degree of

MASTER OF ARTS

Date September 25/84

J. Stanley
Chairman of Examining Board

ABSTRACT

The effects of an eight week endurance training program were compared between a group of formerly-active subjects (i.e., had participated in activity that demanded an energy expenditure of at least seven METS, for a minimum of three to four months per year for at least two years) and a group of subjects who had never participated in physical training on a regular basis. All subjects were male, 30 to 39 years old and had led relatively sedentary lifestyles for at least the last ten years. Variables measured included $\dot{V}O_2$max (both rate and amount of improvement), aerobic (AerT) and anaerobic (AnT) thresholds (relative and absolute values), body weight and estimated body fat, total mean power output per training session and attitude toward physical activity.

Training programs were conducted (employing stationary bicycle ergometers) which were identical for both groups in terms of duration, intensity and frequency. Progressive work tests to exhaustion were administered before, during and after training to measure changes in $\dot{V}O_2$max and in the thresholds.

It was observed that the formerly-active group demonstrated a greater and more rapid percentage increase in $\dot{V}O_2$max than did the sedentary group; however there were no significant differences between groups in absolute (l.min^{-1}) or relative $\dot{V}O_2$max (ml.kg.$^{-1}$min^{-1}) pre- or post-training. The formerly-active group also maintained lower relative AerT and AnT values throughout the training period.

It was concluded that people who were at one time physically active on a regular basis are not more trainable in either absolute (l.min^{-1}) or relative (ml.kg.$^{-1}$min^{-1}) $\dot{V}O_2$max than their more sedentary contemporaries although the formerly-active group did demonstrate a greater increase in $\dot{V}O_2$max when expressed as percent improvement, and also seemed to improve more rapidly in the initial four weeks of training.

ACKNOWLEDGEMENTS

The author wishes to express thanks to Dr. J.S. Skinner for the initial guidance offered to this project and to Dr. Earl Noble for his patience and excellent assistance during the remainder of the investigation.

Thanks to Tom McLellan, Leigh Bumstead and Thom Ferroah for their technical assistance and advice.

I would also like to extend a special thank you to my parents for their continued encouragement and moral support through the long haul.

The excellent work of Mrs. Barbara Lewis in typing this manuscript is gratefully acknowledged.

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CHAPTER I INTRODUCTION

A statement which is often made but has never been scientifically substantiated is that people who have, at one time been regularly physically active can improve their maximal aerobic power more rapidly and to a greater entent than those individuals who have never trained on a regular basis. Training studies employing a direct-comparison approach between formerly-active persons and sedentary individuals are non-existant.

Recently, a great deal of time and effort has been devoted to a physiological phenomenon termed "anaerobic threshold" which has been proposed as being at least partially responsible for individual variation in response to endurance training (McLellan and Skinner, 1981) and has been positively correlated to endurance performance (Sjodin and Jacobs, 1981). The anaerobic threshold (AT) may be measured by non-invasive gas-exchange methods or invasively by blood lactate analysis and is generally agreed to be the point during incremental exercise at which energy demands cannot be met aerobically and there is a shift in muscle metabolism leading to increased lactic acid production (Karlsson and Jacobs, 1982). Despite general acceptance of the threshold concept, considerable controversy surrounds various factors petaining to the AT, e.g., whether or not there are one or two thresholds, methods used to measure the AT, changes in the AT resulting from endurance training and whether or not the AT is correlated to $\dot{V}O_2$max, per cent slow-twitch (ST) fibre composition and/or % ST fibre area and oxidative enzyme activity.

The purpose of the present investigation was to determine whether or not formerly-active individuals are more trainable (i.e., can increase their maximal aerobic power more rapidly and to a greater extent than their more sedentary contemporaries when both groups are assigned to identical endurance training programs). In addition to this, it was hoped that the data collected on anaerobic threshold might help to clear up some of the controversy surrounding this phenomenon.

CHAPTER 2 REVIEW OF LITERATURE

Physiological differences between athletic and sedentary people have been well-documented. Some of the major differences which have been observed for example, are that athletes have a higher maximal aerobic power ($\dot{V}O_2$max), larger heart volumes, lower resting heart rates, higher than average values for some pulmonary functions and a lower per cent body fat (Grimby and Saltin, 1966; Saltin and Grimby, 1968; Skinner, 1973). Physiological alterations caused by discontinued regular physical activity have also been vigoursly analyzed. Pedersen and Jorgensen (1978) noted that the improvement in VO_2max which resulted from training may be totally negated with a respite as short as seven weeks. Dill *et al*. (1969) observed that the maximal aerobic power of four former university athletes had declined to near average values after discontinuing training during the intervening 20 years. This observation was confirmed during re-testing in 13 former champion runners 25-43 years after they had ceased to compete (Robinson *et al*., 1976). While the physiological consequences of training and detraining have been established, the question as to whether regular participation in vigorous physical activity followed by several years of sedentary activity patterns will enable the formerly-active (FA) individual to improve his $\dot{V}O_2$max to a relatively greater extent and/or more rapidly than his sedentary contemporary has not been answered.

2-1 Training Effects

Major training effects (physiological adaptations) resulting from a typical 8-10 week training program should include an increase in maximal aerobic power of 4-50% depending upon the age and initial fitness ($\dot{V}O_2$max) of the individual (Saltin et al., 1969). The improvement in $\dot{V}O_2$max may be attributed to various biochemical (increased oxidative enzyme activity, increased mitochondrial size and number) and circulatory (improved stroke-volume and capillary to fibre ration) adaptations (Åstrand and Rodahl, 1977). Other significant training effects include minor alterations in body weight and body composition, reduced heart rate at rest and during submaximal work, as well as increases in the aerobic (AerT) and anaerobic (AnT) thresholds as defined below (Åstrand and Rodahl, 1977; Davis *et al*., 1979; Skinner and McLellan, 1980).

2-2 Thresholds

While most investigators are willing to accept the concept of an anaerobic threshold (AT), a certain degree of controversy still surrounds this physiological phenomenon and is reflected in the bewildering array of labels applied to it. The anaerobic threshold has been termed the aerobic threshold (Skinner and McLellan, 1980; McLellan and Skinner, 1981), the aerobic-anaerobic threshold (Kinderman _et al_., 1979), the onset of blood lactate accumulation - OBLA (Sjodin and Jacobs, 1981; Sjodin _et al_., 1981; Karlsson and Jacobs, 1982), individual anaerobic threshold - IAT (Stepman _et al_., 1981), ventilatory anaerobic threshold - VAT (Green _et al_., 1983) and blood lactate anaerobic threshold - LAT (Green _et al_., 1983). This diversity of labels is a reflection of the varied criteria used to determine the onset of the anaerobic threshold.

Presently, the most widely-accepted criteria for gas-exchange determination of the AT are those of Davis _et al_. (1979), i.e., a systematic increase in the ventilatory equivalent for O_2 ($\dot{V}E/\dot{V}O_2$) without an increase in the ventilatory equivalent for CO_2 ($\dot{V}E/\dot{V}O_2$) and a systematic increase in end-tidal PO_2 (PET_{O_2}) without a decrease in PET_{CO_2} (Yeh et al., 1983). However, some investigators have more simply defined the AT as occurring at the initial break in $\dot{V}E/\dot{V}O_2$ (Green et al., 1983) or as a systematic increase in $\dot{V}E/\dot{V}O_2$ without a corresponding increase in $\dot{V}E/\dot{V}CO_2$ (Ready and Quinney, 1982). Similar discrepancies between investigators are also apparent when comparing invasive methods of AT determination. Some studies have employed an absolute lactate threshold criteria of either 2mM (Skinner and McLellan, 1980) or 4mM (Kindermann et al., 1979; Rusko et al., 1980), while others have simply employed a lactate break-point (Green et al., 1983; Davis et al., 1983).

Davis et al. (1983) concluded that the anaerobic threshold does not occur at a fixed lactate concentration due to individual lactate kinetics (i.e., varying rates of lactate release and uptake). In fact, it has been observed that some individuals are incapable of achieving a blood lactate concentration of 4mM, even during maximal exercise (Rusko et al., 1980; Davis et al., 1983).

Perhaps the most significant dispute in recent literature involves the existence of one or two thresholds. Kindermann et al. (1979), Skinner and McLellan (1980) and McLelland and

Skinner (1981) have defined two distinct ventilatory break-points or thresholds. Thus the aerobic threshold (AerT) of Kindermann, Skinner and McLellan is the equivalent of the anaerobic threshold of Wasserman et al. (1973) and Davis et al. (1979). The existence of a second break-point has generally been ignored by other investigators although Orr et al. (1982) observed that a 3-line regression (2 break-point) model was more applicable to the $\dot{V}E/\dot{V}O_2$ relationship during progressive exercise than a 2-line, one break-point analysis.

There is also controversy over whether or not gas-exchange and blood lactate determinations of the anaerobic threshold are closely correlated. Davis et al. (1976) observed a correlation co-efficient of 0.95 between gas exchange and blood lactate determinations of the AT. This finding was corroborated by Ivy et al. (1981) and Davis et al. (1983). Other investigators, however, have documented significant time differences between the increase in muscle lactate, blood lactate and $\dot{V}E/\dot{V}O_2$ (Green et al., 1983). Green et al. (1983) concluded that the lactate threshold and ventilatory threshold do not occur simultaneously. Yeh et al.

(1983) observed that there was no definitive break in arterial lactate and also that venous lactate accumulations lagged behind arterial accumulations by approximately 90 seconds. These same authors concluded that the subjective evaluation of gas exchange criteria for anaerobic threshold resulted in too much variability to be of any clinical use. Karlsson and Jacobs (1982) advocate long work periods and small workload increments (i.e., 4 min, 50w) in a progressive exercise test protocol to allow for equalization of muscle and blood lactate concentrations. The test protocols used by both Green et al. (1983) and Yeh et al. (1983) employed relatively short work periods ($1.min.^{-1}$) which could account for the lack of a significant relationship between ventilatory (VAT) and lactate (LAT) AT's in these studies. However, Davis et al. (1976) and Ivy et al. (1981) used similar test protocols and still evolved significant correlations between VAT and LAT. The explanation for this discrepancy must therefore evolve from some factor other than test protocol.

Mean relative values for AT (% $\dot{V}O_2$max) in healthy subjects range from 37.4% (Kindermann et al., 1979; Yoshida et al., 1982) to 65.0% (Tesch et al., 1981). Absolute values of AT ($l.min^{-1}$) fall between 1.0 ($l.min^{-1}$) (Wasserman et al., 1973; Yoshida et al., 1982)and 2.43 ($l.min^{-1}$) (Tesch et al., 1981; Green et al., 1983). Various investigators have attempted to correlate the AT with maximal aerobic power, the hypothesis being that well-trained individuals should be able to work at relatively higher workloads without experiencing significant lactate accumulations. Ivy et al. (1980) observed a very strong correlation between $\dot{V}O_2$max ($ml.kg.^{-1}min^{-1}$) and lactate threshold ($ml.kg.^{-1}min^{-1}$) ($r = 0.91$). A high positive correlation ($r = 0.85$) was also documented by Weltman and Katch (1979). Other investigators however, have reported only moderate ($r = 0.72 - 0.75$, Davis et al., 1979) or low ($r = 0.52$, Davis et al., 1976) correlations between these two variables. In fact, researchers who have documented high values for AT (% $\dot{V}O_2$max), have reported relatively low values for $\dot{V}O_2$max, i.e. Tesch et al. (1981) reported values of 65% $\dot{V}O_2$max for the AT but the mean $\dot{V}O_2$max for his sample was only 48.7 ($ml.kg.^{-1}min^{-1}$) and Ready and Quinney (1982) reported values of 64.9% $\dot{V}O_2$max and 45.7 ($ml.kg.^{-1}min^{-1}$) for the AT and $\dot{V}O_2$max respectively. Thus, it would appear that more comprehensive research is required before any definitive statement may be made about the relationship betwen $\dot{V}O_2$max and AT.

Since endurance athletes tend to have higher than average per cent slow-twitch (ST) muscle fibre composition (Gollnick et al., 1972; Saltin et al., 1977), attempts have been made to correlate the onset of the thresholds to per cent ST fibre composition or % ST muscle fibre area with varying degrees of success. Correlation co-efficients of 0.74 and 0.70 were reported by Ivy et al. (1980) between % ST fibre composition and absolute and relative thresholds respectively. Tesch et al. (1981) documented a moderate correlation (r= 0.75) between OBLA (% $\dot{V}O_2$max) and % ST muscle fibre area. However, other investigators have reported non-significant correlations between these two variables (Green et al., 1979; Rusko et al., 1980; Skinner and McLellan, 1980).

Oxidative enzyme activity has also been postulated as a potential explanation for individual threshold variation. It has been well-documented that endurance training is a stimulus for enhancing the oxidative enzyme activity of both slow and fast-twitch fibres (Gollnick et al., 1972; Saltin et al., 1977; Weltman et al., 1978). However, Rusko et al., (1980) found only a moderate correlation ($r = 0.63$) between SDH activity and AnT and CS and AT ($r = 0.58$), while Green et al., (1979) found an insignificant relationship between the two variables. Sjodin et al. (1981) also reported an insignificant correlation between oxidative enzyme activity (citrate synthase) and VOBLA (running velocity at which OBLA occurred) ($r = 0.33$). Thus, it would appear that the relationship between AT and oxidative enzyme activity is tenuous, i.e., the available evidence is inconclusive.

Recent evidence has indicated that the onset of the AT is also affected by substrate availability (Ivy et al., 1981; Hughes et al., 1982). Ivy et al. (1981) concluded that the onset of the LAT could be significantly delayed by elevating blood levels of free fatty acids (FFA). The LAT occurred at 53.9% $\dot{V}O_2$max in the control trial and 59.8% in the high FFA trial. Hughes et al. (1982) demonstrated that the LT (lactate threshold) could be significantly increased in a glycogen-depleted state. The authors speculate that increased lipid oxidation during exercise may have slowed the rate of glycolysis and reduced lactate production.

Although it is generally believed that the anaerobic threshold may be significantly altered with endurance training, there is some evidence to the contrary. McLellan and Skinner (1981) reported negligible changes in relative AT (identified as AerT by McLellan and Skinner) following eight weeks of endurance training in young sedentary males. Other investigators however, have documented significant increases in relative and absolute AT following endurance training. Davis et al. (1979) observed a 15% improvement in relative AT and a 44% increase in absolute AT following 9 weeks of endurance training. Ready and Quinney (1982) reported increases of 19.4% and 70.4% for relative and absolute AT respectively after 9 weeks of training. One possible explanation for the conflicting results may be that subjects in the studies by Davis et al. (1971) and Ready and Quinney (1982) trained at relatively higher intensities (75-85% $\dot{V}O_2$max) more frequently (four times per week) than did the subjects trained by McLellan and Skinner (1981).

It is apparent that a fairly high level of controversy still surrounds the concept of the anaerobic threshold and there is a great deal of conflicting evidence on several dimensions of this phenomenon.

2-3 Leisure Energy Expenditures

Montoye et al., (1962) collected data via questionnaire from 1,191 University of Michigan alumni and reported that in terms of leisure sports participation, former athletes were slightly more active than non-athletes up to age 45, at which point the trend reversed itself. In terms of leisure time non-sports activity, however, non-athletes of all ages reported greater participation in the mean number of hours per day spent in mild, moderate and vigorous activity.

2-4 Body Weight and Composition

Montoye et al., (1962) observed that college athletes were significantly heavier than non-athletic controls by approximately 5 kilograms. Once an athlete ceases to compete, however, there is generally a reduction in muscle mass (due to muscle fibre atrophy) and a significant increase in body weight (Saltin and Grimby, 1968; Robinson et al., 1976). Montoye et al. (1962) observed that former athletes and non-athletes exhibited similar weight gains following graduation and weight gains were approximately linear up to age 65, at which time the mean annual increases in weight were much less for both groups. Thus, while athletes generally tend to be heavier than the average non-athletic population throughout their lives, it is not clear whether formerly-active persons have significantly different percentages of body fat than their sedentary contemporaries.

2-5 Attitudes Toward Exercise

There have been several studies on the attitudes of active and sedentary people, as well as changes in attitudes that accompany regular physical activity. Harris (1970) found that men who had been active throughout their lives had attitudes toward physical activity that were distinctly more positive than those espoused by men who had been relatively sedentary. When the previously sedentary individuals in this study were placed on a 'regular, vigorous' exercise program for one year, they experienced changes in attitude toward physical activity which then more closely resembled those of active individuals. MacPherson et al. (1967) studied the effects of exercise on post-infarct and normal adult men. After 24 weeks of activity, it was observed that the cardiac exercise group experienced more favourable personality changes (eg. they were less tense, less anxious and more alert) than all other groups (cardiac controls, normal controls, normal exercisers and experienced exercisers). All subjects exhibited favourable mood changes following a single session of exercise.

2-6 Summary

This review has established that direct comparison training studies of alterations in physiological parameters between formerly-active and sedentary subjects do not exist. It is also apparent that considerable controversy surrounds many variables pertaining to anaerobic threshold; perhaps the most significant dispute for the present investigation involves the existence of one or two thresholds or ventilatory break-points.

Former athletes and non-athletes have been directly compared to each other on the basis of leisure energy expenditure, body weight and attitude toward physical activity, however, the literature is relatively sparse.

Chapter 3. Methods

3.1 Subject Recruitment

Volunteers were recruited via advertisements placed in local and campus newspapers, notices posted around the campus, in major industrial plants throughout the city and on local cablecast programs. The notices specified that all volunteer be male, 30 - 39 years old and not have been physically active on a regular basis for the past 10 years.

3.2 Subject Classification

All volunteers were placed in one of three categories based on past and present activity patterns. Aside from being male and 30-39 years of age, there were two criteria which each subject had to meet in order to qualify for inclusion in the study. First, all subjects had to have been 'relatively sedentary' for the past 10 years. This was a subjective evaluation, independently determined by two investigators. The evaluation was based on the results of an interview where the volunteer was closely questioned about his activity patterns over the past 10 years. If either one of the two investigators determined that the volunteer had been too active, then he was disqualified from further participation. Second, volunteers were also disqualified if it was determined that they had not been active enough to qualify for the formerly-active group (see criteria outlined below) but had been too active to be included in the sedentary group.

The formerly-active group (FA) consisted of men who had trained a minimum three to four months per year for at least two years in an activity classified as demanding an energy expenditure of at least seven METS (see Appendix 1. Average Metabolic Cost of Activities). The sedentary group (SED) had never participated in any strenuous sports or recreational activities on a regular basis.

3.3 Screening

All subjects underwent a preliminary screening procedure involving a resting 12-lead ECG, a submaximal exercise ECG while riding a bicycle ergometer, resting and exercise blood pressures, pulmonary function tests (FVC, FEV_1, FEV_3, MVV) and body composition estimated from 10 skinfolds according to the formula of Allen et al. (1956) (see Table 1. Study Design). All of them then completed a health history questionnaire and provided information via interview on past sports participation, previous occupations (including summer employment) and

TABLE 1. STUDY DESIGN

	WEEK		
	0	4	8
A. Background Information			
1. Informed consent	X	X	X
2. MacPherson-Yuhasz questionnaire	X		X
3. Health hazard appraisal	X		
4. Medical history	X		
5. Past history of physical activity	X		
6. Occupational energy expenditure	X		
B. Screening			
1. Resting blood pressure	X		
2. 12-lead ECG	X		
3. Pulmonary function	X		
4. Body weight and composition	X		X
5. Submaximal bicycle ergometer test (predicted $\dot{V}O_2$max, exercise ECG and BP)	X		
C. $\dot{V}O_2$max tests			
1. $\dot{V}O_2$max test (thresholds from gas exchange at 0 and 8 weeks)	X	X	X

physical activity patterns. In addition, each individual signed an informed consent form agreeing to undergo the maximal aerobic testing procedure. A physician examined the pertinent data (resting 12-lead ECG, submaximal exercise ECG, resting and exercise blood pressures and pulmonary function tests) and gave written permission for further participation in the study. The physician was also present for the first test of maximal aerobic power ($\dot{V}O_2$max) and any other tests he deemed necessary.

3.4 Maximal Oxygen Uptake ($\dot{V}O_2$max) Testing Procedure

Each subject completed two $\dot{V}O_2$max tests on the bicycle ergometer prior to training, one test at four weeks into training and two more tests following completion of the eight week training program. The means of the two pre-training and two post-training tests were taken to be representative of the respective $\dot{V}O_2$max values. When the values of the two tests differed by more than 2 $ml.kg^{-1}.min^{-1}$, a third test was conducted and the mean of the two closest tests was selected.

The pedalling frequency on the bicycle was set at 60 rpm. The test protocol entailed having the subject pedal initially for three minutes at 180 kpm. Every two minutes thereafter, the workload was increased by 180 kpm. The test was terminated when the subject indicated he was exhausted and could no longer continue or if the technician observed that the subject could no longer maintain the pedalling frequency.

During the test, the subject was equipped with a nose-clip and supportive head gear and was required to breathe through a rubber mouth-piece attached to a low-resistance Koegel 'Y' respiratory valve. To measure flow rate, the inspiratory side of the valve was connected to a Hewlett-Packard pneumotachometer (Model 21073A), which was attached to an H-P flow transducer (Model 47304A). Expired air, having passed through a mixing chamber and two tubes of anhydrous $CaSO_4$, was analyzed for O_2 and CO_2 gas concentrations by an electrochemical O_2 analyzer (Applied Electrochemistry Inc., Model S-3A) and an infrared Godart Capnograph (type BE). Both analyzers were calibrated before each test with standardized gases that had previously been analyzed using the micro-Scholander technique. The pneumotachometer was calibrated with a syringe containing a known volume of air. Heart rate was monitored continuously throughout the test from a modified CM-5 lead on a Westinghouse ECG oscilloscope (Model 304) and was recorded during the final 15 seconds of each workload with a Fukunda ECG (Model FJC-7110). The oscilloscope, flow transducer, O_2 and CO_2 analyzers were each connected to a four-channel H-P A/D converter (Model 47310A), which was connected in turn to an H-P mini-computer (Model 9825A) and printer (Model 9871A). $\dot{V}_I$, F_EO_2, F_ECO_2 and HR were determined and values were displayed on the mini-computer at the end of each 30-second work period. Following the completion of the test, $\dot{V}_E$, $\dot{V}O_2$ ($l.min^{-1}$, $ml.kg^{-1}min^{-1}$, METS), $\dot{V}CO_2$, R, F_EO_2, F_ECO_2, HR tidal volume (TV) and respiratory frequency were calculated and printed.

3.5 Pulmonary Function Test

Each subject was required to complete one set of pulmonary function tests prior to training. FVC, FEV_2, FEV_3 and MVV were measured for each subject. This data was used as part of the medical screening all subjects were required to undergo.

3.6 Aerobic (AerT) and Anaerobic (AnT) Threshold Determinations

The AerT as defined by Skinner and McLellan (1980), is characterized by changes in many variables, e.g., non-linear increases in VE and $\dot{V}CO_2$ relative to $\dot{V}O_2$, a slight increase in blood lactate concentration above resting values and an increase in F_EO_2 without a corresponding decrease in F_ECO_2. For the purpose of this investigation, the aerobic threshold was determined at the onset of the first non-linear increase in

$\dot{V}E/\dot{V}O_2$. The AnT was determined at the onset of the second non-linear increase in $\dot{V}E$ relative to $\dot{V}O_2$ and a decrease in F_ECO_2. The only time the blood lactate concentrations were used to help ascertain the AerT and AnT were in situations where there were no definitive breaks in $\dot{V}E/\dot{V}O_2$ (i.e., a curvilinear relationship was apparent).

Threshold determinations were independently ascertained visually by two investigators. Where values differed by more than five percent of $\dot{V}O_2$max, a third estimation was obtained and the mean of the two closest values was recorded.

3.7 Training Protocol

Following completion of the two pre-training $\dot{V}O_2$max tests, a summary HR-$\dot{V}O_2$ graph was constructed for each subject from both tests to determine the training $\dot{V}O_2$ and its corresponding heart rate.

All training was conducted on a stationary bicycle ergometer at 60 rpm. Training sessions consisted of 30 minutes of continuous cycling at a resistance designed to elicit 60% $\dot{V}O_2$max for week one, 65% for week two and 70% for weeks three and four. After four weeks of training, each subject performed one more $\dot{V}O_2$max test, from which a new HR-$\dot{V}O_2$ graph and corresponding training HR were calculated. During weeks five to eight, subjects trained at an HR calculated to elicit

75% of the $\dot{V}O_2$max determined at the fourth week. Each subject completed three training sessions per week for a total of 24 sessions. Heart rate was monitored every three minutes throughout the training period to ensure that the prescribed training intensity was maintained. If the HR varied from the prescribed training HR, bicycle resistance was altered accordingly.

3.8 Post-training Testing

Upon completion of the training program and the two post-training $\dot{V}O_2$max tests, each subject had his skinfolds measured for the estimation of percent body fat and once again completed the MacPherson-Yuhasz questionnaire (see Table 1. Study Design).

3.9 Statistical Analysis

A 2X3 ANOVA ($\alpha=0.05$) split-plot design with repeated measures was utilized to determine the significance of any differences in $\dot{V}O_2$max, AerT and AnT between the two groups at zero, four and eight weeks. If a significant interaction effect existed, a post-hoc Scheffe analysis ($\alpha=0.05$) was employed to determine the source.

A 2X2 ANOVA ($\alpha=0.05$) was used to determine differences in % body fat and attitude toward physical activity as measured by the MacPherson-Yuhasz Questionnaire.

Reliability was ascertained for the two pre-training $\dot{V}O_2$max tests, as well as for the intra- and inter-observer measurements of the pre-training AerT and AnT.

A correlation analysis was performed to compare % increase in $\dot{V}O_2$max with age, initial fitness ($\dot{V}O_2$max) and mean total power output; AerT ($l.min^{-1}$ and %$\dot{V}O_2$max) to $\dot{V}O_2$max for both groups pre- and post-training and AnT ($l.min^{-1}$ and %$\dot{V}O_2$ max) to $\dot{V}O_2$max pre- and post-training.

CHAPTER 4. RESULTS

4-1 Description of Subjects

Thirty-three volunteers were found suitable for the initial screening process. Based on past athletic participation (or lack thereof) and leisure energy expenditure over the last 10 years, 25 men qualified for inclusion in the training study. The eight subjects that were disqualified failed to meet the requirements of the study in that they either had maintained a level of leisure energy expenditure over the past decade that was too high to qualify as sedentary or else their prior athletic participation failed to meet the specifications outlined below. The 25 volunteers who qualified were male, 30-39 years old and had been sedentary for the past 10 years. Thirteen subjects had never been physically active on a regular basis and were thus placed in the sedentary (SED) group. Twelve subjects qualified for inclusion in the formerly-active (FA) group on the basis of reported participation in a sport requiring an energy expenditure of at least seven METS, three to four months per year for at least two years. Four subjects dropped out of the study (two from each group) leaving 11 subjects in the SED group and 10 in the FA group.

It was conceivable that a subject who was categorized as being sedentary may have had an extremely high energy expenditure at work, i.e., approaching that of regular athletic participation (e.g., for three months on a summer job while attending school). In order to determine whether this was a confounding variable, each subject was questioned about his past occupational history. Only two subjects reported working at heavy manual labour in the past; both of these men were in the FA group. With one exception, all subjects were either employed in white-collar occupations or were graduate students at the time of the study (see Appendix II). One subject was employed in a blue-collar occupation (lithorapher), however, it did not require a high energy expenditure (approximately three METS). Despite efforts to obtain a representative cross-section of the general population for the training program (i.e., the placement of notices in factories, cablecast programs, newspapers, etc., was designed to reach a broad spectrum of people), the training sample was heavily biased in favour of white-collar, college graduates of middle and upper-middle socio-economic status. All subjects were high school graduates and 20 of 21 had had some form of post-secondary education.

The athletic profiles of each subject in the FA group are presented in Appendix III. Two subjects reported participation in swimming, one was a soccer goal-keeper, three subjects played football, two were involved in racquet sports (tennis, badminton), one was an intercollegiate varsity wrestler and one played club and school rugby in New Zealand. Four subjects reported participation in more than one sport.

All subjects were also asked to indicate the major reason they had never or no longer participated in sport or physical activity. Twenty of the 21 subjects responded and their answers are presented in Appendix VIII. Both groups had similar reasons for not participating in regular physical activity, the most common being laziness and lack of time, followed closely by lack of opportunity and lack of facilities.

Pre-training values for age, body weight, estimated body fat, and attitude toward physical activity are presented in Table 2. There was no significant difference between groups for any of these variables.

Pre-training values for HRmax, $\dot{V}O_2$max, AerT and AnT are presented in Table 3. The FA group had significantly lower values for relative AerT and AnT.

Table 2: Basic Descriptive Data For Formerly-Active (FA) And Sedentary (SED) Subjects During The Initial Screening Examination

	FA	SED
	(n = 10)	(n = 11)
Age (yrs.)	34.8 ± 0.8 (32-39)	34.1 ± 0.7 (30-38)
Weight (KG.)	89.1 ± 3.7 (81.1 - 103.8)	83.6 ± 5.2 (63.2 - 119.7)
Estimated Body Fat (%)	24.7 ± 0.5 (18.5 - 31.0)	23.7 ± 1.5 (12.2 - 30.0)
Attitude Towards Physical Activity (Total Score out of 250)	193.5 ± 3.5 (178 - 215)	194.6 ± 5.1 (171 - 224)
Blood Pressure (mm Hg)	$\frac{125}{84}$ ($^{116}/_{78}$- $^{138}/_{96}$)	$\frac{121}{82}$ ($^{116}/_{74}$- $^{126}/_{90}$)

All values are ∓ ± SD and the (range)

Table 3: Pre-Training Physiological Data For Formerly-Active (FA) And Sedentary (SED) Subjects Prior To Training

	FA (n = 10)	SED (n = 11)
HRmax ($b.min^{-1}$)	184.5 ± 2.6 (171 - 195)	186.1 ± 3.1 (158 - 200)
$\dot{V}O_2max$ ($l.min^{-1}$)	2.79 ± 0.10 (2.37 - 3.29)	2.85 ± 0.11 (2.20 - 3.27)
($ml.kg^{-1}min^{-1}$)	32.0 ± 1.7 (23.6 - 40.2)	34.8 ± 1.2 (27.0 - 40.3)
AerT ($l.min^{-1}$)	1.41 ± 0.05 (1.16 - 1.60)	1.60 ± 0.05 (1.30 - 1.90)
(% $\dot{V}O_2max$)	50.8 ± 1.3 (46.0 - 57.6)	56.4 ± 1.1 * (51.4 - 62.3)
AnT ($l.min^{-1}$)	2.21 ± 0.10 (1.78 - 2.69)	2.40 ± 0.11 (1.64 - 2.86)
(% $\dot{V}O_2max$)	79.3 ± 1.7 (71.5 - 85.8)	84.1 ± 1.2 * (74.4 - 88.6)

All values are $\bar{x}$ ± SD and the (range)

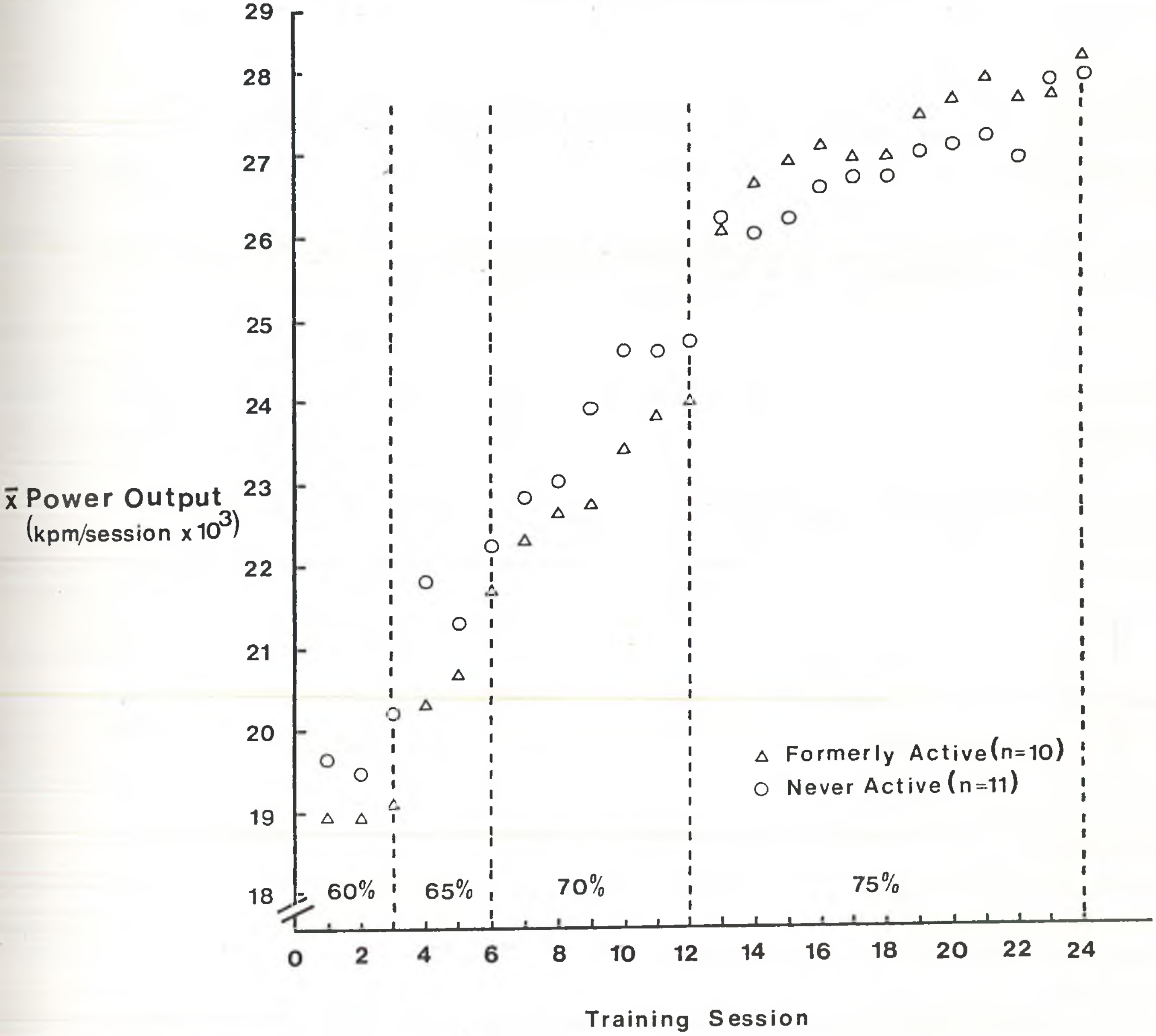
*Significant difference between groups ($p < 0.05$)

Information on reliability and reproducibility of the two $\dot{V}O_2$max tests as well as data on the intra- and inter-observer reliability and reproducibility relative to the thresholds are presented in Appendix IV. There were no significant differences between the two tests for any of the variables. The coefficients of reliability were 0.96 for $\dot{V}O_2$max, 0.86 and 0.92 for AnT and 0.71 and 0.78 for AerT.

4-2 Training Program

Figure 1 documents the changes in mean total power output and mean training heart rate during each 30 minute training session over the eight week program (24 sessions). Since there was no difference in $\dot{V}O_2$max between the two groups and since the training intensity (%$\dot{V}O_2$max) was the same for both groups, there was no significant difference in mean total power output in kpm per 30-minute session. The SED group trained at an insignificantly higher mean total power output of about 500 kpm over the 30-minute session (around 17 $kpm.min^{-1}$) during the first four weeks of training, at which time the trend was reversed and the FA group trained at the insignificantly higher mean total power output of about 300 kpm per 30-minute session or 10 $kpm.min^{-1}$ during the final four weeks of the study (see figure 2).

Figure 1. Mean Power Output per Training Session



This is reflected by the insignificantly higher training heart rates for the SED group up to four weeks and for the FA group from four to eight weeks (see figure 3).

Both groups demonstrated a decline in the heart rate-$\dot{V}O_2$ relationship characteristic of endurance training. For example, despite the fact that training heart rates were held constant over the last four weeks of training, mean total power output continued to increase for both groups (see figure 2).

4-3 Effects of the Training Program

4-3.1 Body Weight and Composition

There were no significant differences between groups prior to, during or after training in either body weight or estimated per cent body fat (see Table 4). With training however, both groups demonstrated a small but significant decline in body weight of approximately one kilogram and in body fat of 1-1.5%.

4-3.2 $\dot{V}O_2$max

Both groups showed significant increases in $\dot{V}O_2$max ($l.min^{-1}$ and $ml.kg.^{-1}min^{-1}$) over the eight weeks of training (see Tables 5 and 6). Pre-, mid- and post-training values for $\dot{V}O_2$max were not significantly different between groups. The FA group had significantly greater relative improvements in $\dot{V}O_2$max from 0-4 weeks (15-16%) and from 0-8 weeks (20-21%). In contrast, the SED group improved at a more uniform rate, exhibiting

Figure 2. Mean Power Output per Week of Training

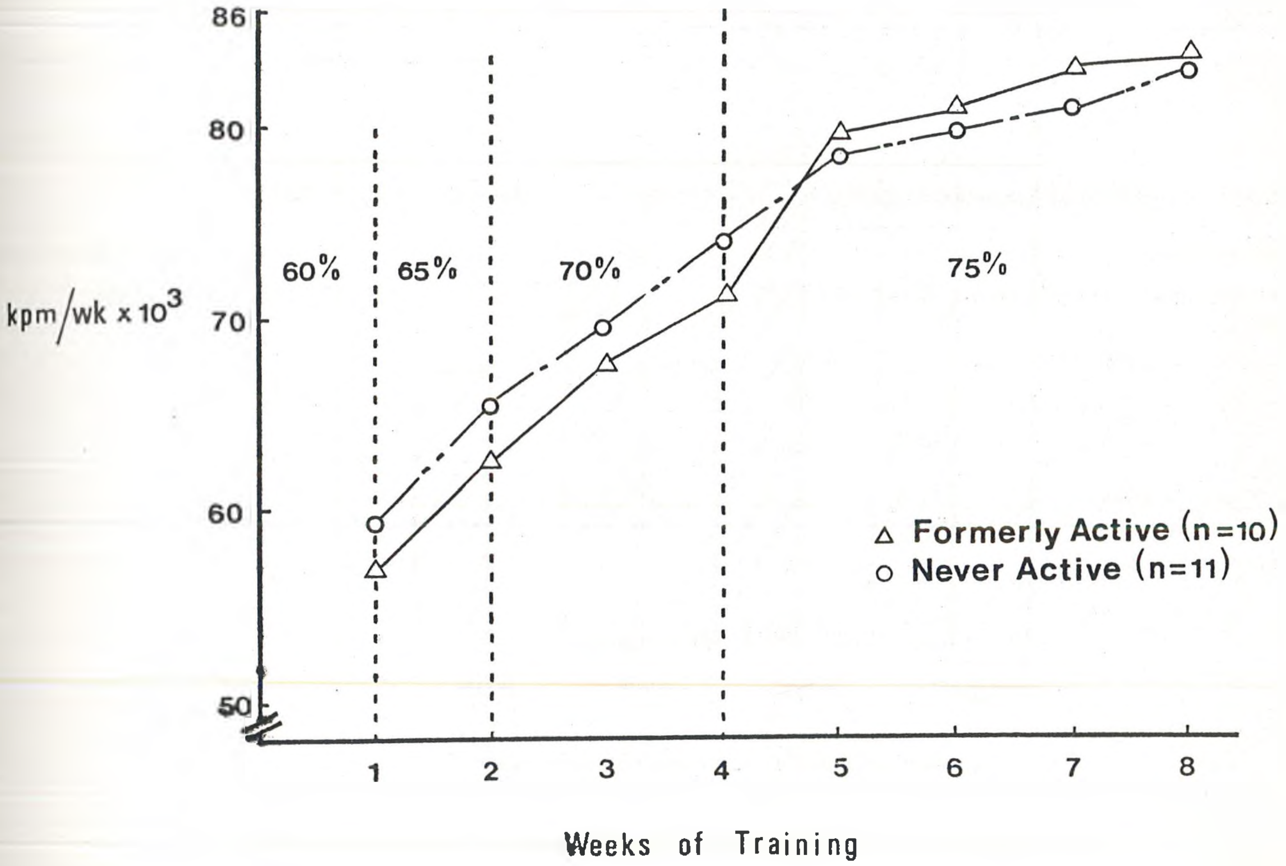


Figure 3. Mean Training Heart Rates

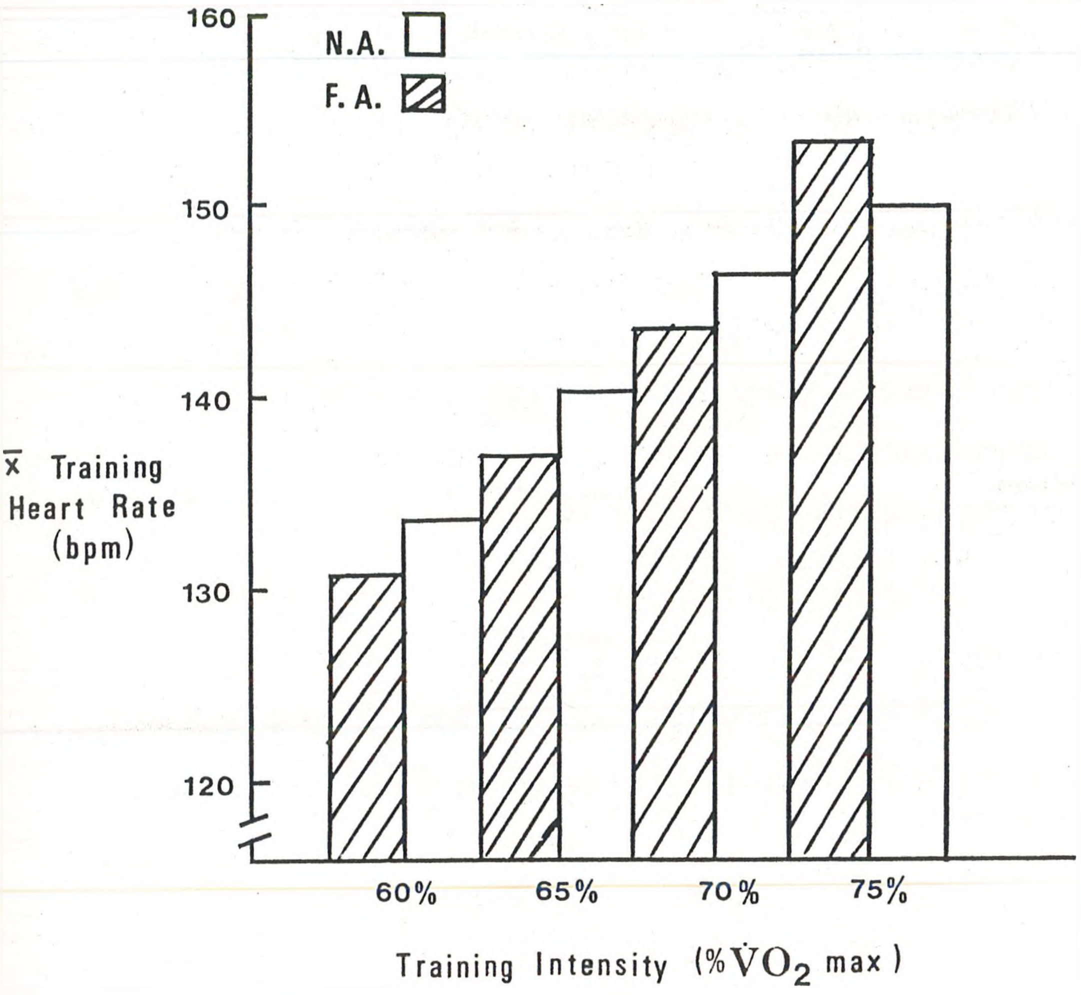


Table 4: The Effects of an Eight-Week Training Program On Body Weight And Estimated Per Cent Body Fat Of Formerly-Active (FA) And Sedentary (SED) Subjects.

	Group	Week of Training		
		0	4	8
Body Weight (kg.)	FA	89.1 ± 3.7	87.4 ± 3.7	88.1 ± 3.9 [a]
	SED	83.6 ± 5.2	82.7 ± 5.3	82.6 ± 5.2 [a]
Estimated Body Fat (%)	FA	24.7 ± 0.5	-	23.6 ± 1.4 [a]
	SED	23.7 ± 1.5	-	22.2 ± 1.4 [a]

All values are $\bar{x} \pm$ SD

[a] Significant differences with training ($p < 0.05$) from weeks 0-8.

Table 5: The Effects Of An Eight-Week Training Program On The $\dot{V}O_2$max Of Formerly-Active (FA) And Sedentary (SED) Subjects.

	Group		Week of Training	
$\dot{V}O_2$max		0	4	8
$l.min^{-1}$	FA	2.79 ± 0.10	3.20 ± 0.17 ^{b}	3.35 ± 0.18 ^{a}
	SED	2.85 ± 0.11	3.00 ± 0.12	3.20 ± 0.11 ^{a}
$ml.kg^{-1}min^{-1}$	FA	32.0 ± 1.7	37.2 ± 2.5 ^{b}	38.8 ± 2.6 ^{a}
	SED	34.8 ± 1.2	36.9 ± 1.3	39.6 ± 1.4 ^{a}

All values are $\bar{x} \pm$ SD

[a] Significant difference 0-8 weeks

[b] Significant difference 0-4 weeks

Table 6: The Effects Of An Eight-Week Training Program On The Per Cent Improvement In $\dot{V}O_2$max Of Formerly-Active (FA) And Sedentary (SED) Subjects.

	Group	Week of Training		
		0-4	4-8	0-8
$l.min^{-1}$	FA	14.8 ± 4.4 [a,c]	5.3 ± 1.2	20.2 ± 4.1 [b,c]
	SED	5.5 ± 1.6 [c]	6.9 ± 0.9	12.7 ± 2.0 [b,c]
$ml.kg^{-1}min^{-1}$	FA	16.0 ± 4.4 [a,c]	4.9 ± 0.91	20.8 ± 3.8 [b,c]
	SED	6.2 ± 1.6 [c]	7.4 ± 1.2	13.8 ± 2.2 [b,c]

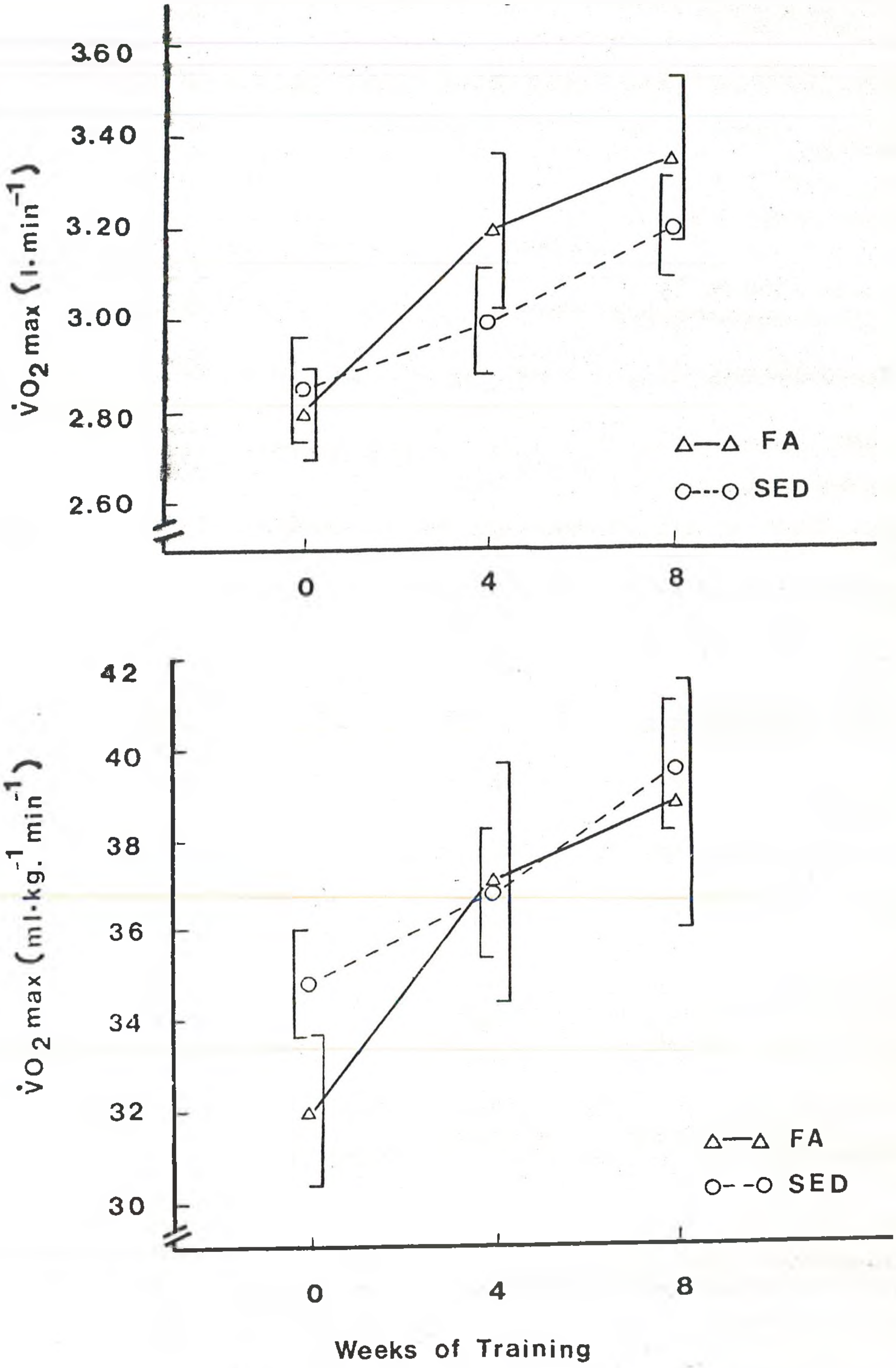
All values are $\bar{x} \pm$ SD

a/ 0-4 weeks $p < 0.05$

b/ 0-8 weeks $p < 0.05$

c/ FA vs SED $p < 0.05$

Figure 4. The Effects of Eight Weeks of Training on $\dot{V}O_2$max



non-significant increases in $\dot{V}O_2$max from 0-4 weeks (5-6%) and a significant improvement over the eight weeks of 13-14%. The amount of improvement in $\dot{V}O_2$max (% increase) was not significantly correlated to either initial fitness ($r = 0.14$) or age ($r = 0.26$) but was moderately correlated to the per cent increase in mean total power output ($r = 0.73$).

4-3.3 Thresholds

In absolute terms, there was no significant difference between groups in AerT ($l.min^{-1}$) at 0, 4 or 8 weeks (see Table 7). Post-hoc analysis indicated that the AerT ($l.min^{-1}$) was not significantly altered from 0-8 weeks for the SED group. The FA group however, showed significant increases from 0-4 and 0-8 weeks in AerT ($l.min^{-1}$). Further analysis indicated that prior to training, AerT ($l.min^{-1}$) was significantly correlated to $\dot{V}O_2$max ($l.min^{-1}$) for the FA group ($r = 0.73$) and for the SED group ($r = 0.90$). After training was completed, the strength of the correlation was unchanged for either group.

When the AerT was expressed relative to $\dot{V}O_2$max ($\dot{V}O_2$max), there were significant differences between groups, in that the SED group had higher pre-, mid- and post-training values (see Table 7).

Both groups demonstrated significant increases in AnT

Table 7: The Effects Of An Eight-Week Training Program On The Aerobic Threshold (AerT) Of Formerly-Active (FA) And Sedentary (SED) Subjects.

	Group	Week of Training 0	4	8
AerT $1.min^{-1}$	FA	1.41 ± 0.05	1.57 ± 0.06 [a]	1.64 ± 0.01 [b]
	SED	1.60 ± 0.05	1.65 ± 0.06	1.67 ± 0.07
$\% \dot{V}O_2max$	FA	50.78 ± 1.31 [c]	50.91 ± 2.01 [c]	49.74 ± 2.12 [c]
	SED	56.41 ± 1.06 [c]	55.21 ± 1.17 [c]	52.18 ± 1.02 [c]

All values are $\bar{x}$ ± SD

a. 0-4 weeks $p < 0.05$

b. 0-8 weeks $p < 0.05$

c. FA vs SED $p < 0.05$

Figure 5. The Effects of Eight Weeks of Training on Aerobic Threshold (AerT)

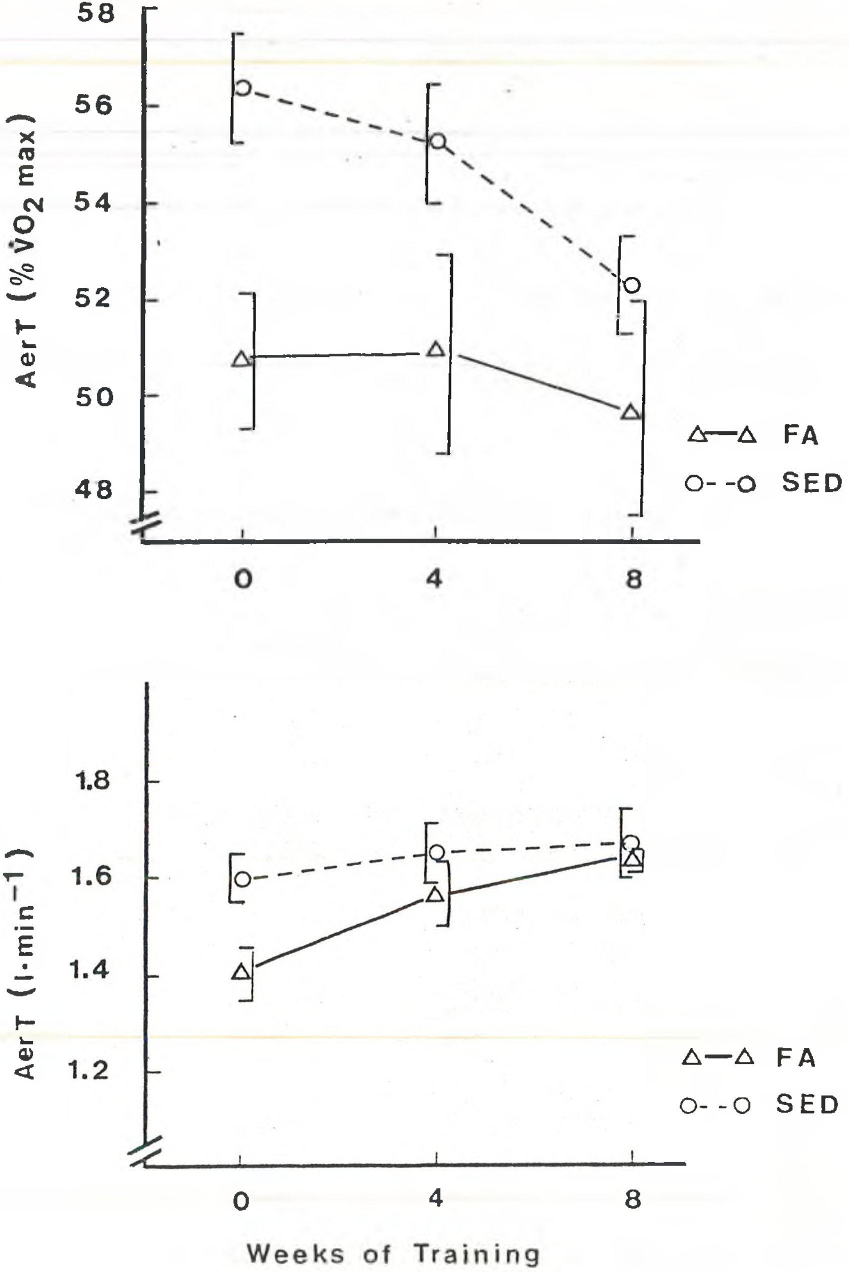
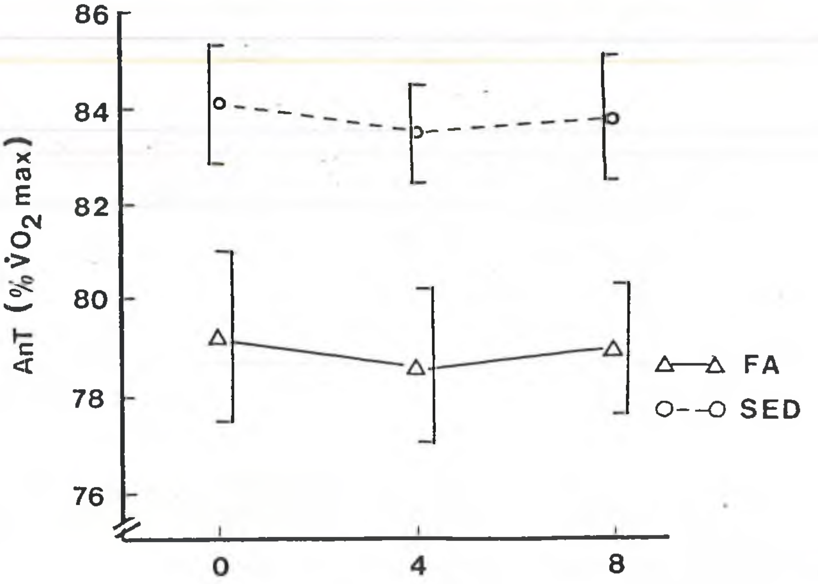
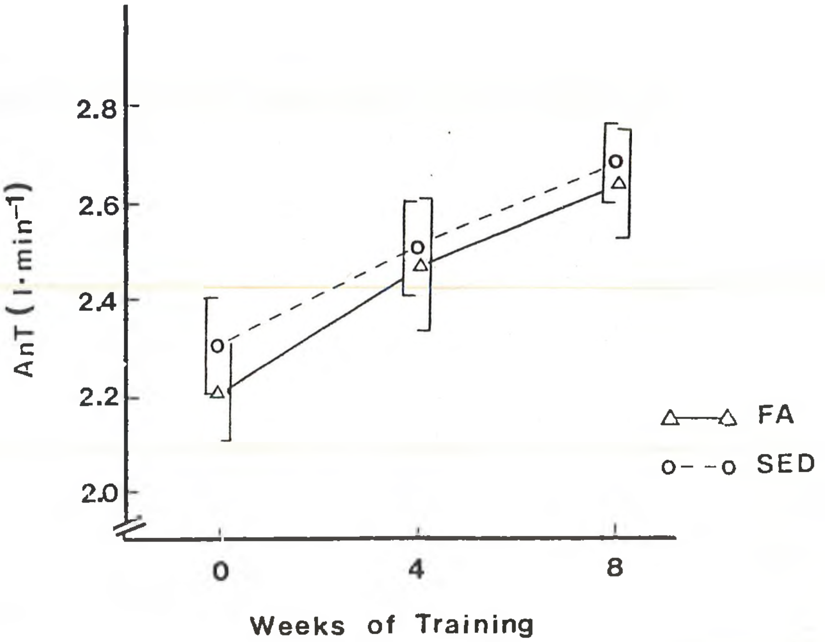


Figure 6. The Effects of Eight Weeks of Training On Anaerobic Threshold (AnT)





($l.min^{-1}$) with training (see Table 8), but there were no significant differences between groups. AnT ($l.min^{-1}$) was strongly correlated to $\dot{V}O_2$max for both groups pre- and post-training (FA group: r = 0.94 pre-training and r = 0.96 post-training; SED groups: r = 0.96 pre-training and r = 0.92 post-training).

When AnT expressed relative to $\dot{V}O_2$max, the SED group had significantly higher values at 0, 4 and 8 weeks (see Table 8). There was no significant change in AnT (%$\dot{V}O_2$max) with training for either group. Prior to training AnT (%$\dot{V}O_2$max was not significantly correlated to $\dot{V}O_2$max ($l.min^{-1}$) for either group. This relationship was not altered with training.

Blood lactate values were only required to aid in establishing the AerT of two individuals (see Appendix IX) who did not exhibit definitive break-points in $\dot{V}E/\dot{V}O_2$.

4-3.4 Attitudes

Data on the attitude toward physical activity pre- and post-training are presented in Table 9. ANOVA ($p<0.05$) revealed no significant difference between groups before of after training. Also, there was no change in attitude over the eight week training program for either group, however, values were high revealing a positive attitude.

Table 8: The Effects Of An Eight-Week Training Program On The Anaerobic Threshold (AnT) Of Formerly-Active (FA) And Sedentary (SED) Subjects.

	Group	Week of Training		
AnT		0	4	8
$l.min^{-1}$	FA	2.21 ± 0.10	2.47 ± 0.13^{a}	2.62 ± 0.11^{b}
	SED	2.40 ± 0.11	2.50 ± 0.09	2.67 ± 0.08^{b}
% $\dot{V}O_2max$	FA	79.34 ± 1.67^{c}	78.53 ± 1.64^{c}	78.88 ± 1.36^{c}
	SED	84.07 ± 1.22^{c}	83.43 ± 0.95^{c}	83.68 ± 1.27^{c}

All values are $\bar{x} \pm SD$

a. 0-4 weeks, $p < 0.05$

b. 0-8 weeks, $p < 0.05$

c. SED vs FA, $p < 0.05$

Table 9: The Effects Of An Eight-Week Training Program On The Attitude Toward Physical Activity Of Formerly-Active (FA) And Sedentary (SED) Subjects, as Measured by the MacPherson-Yuhasz Questionnaire.

Group		Pre-Training	Post-Training
Attitude Score (out of 250)	FA	193.5 ± 3.5	192.7 ± 2.5
	SED	194.6 ± 5.1	194.0 ± 4.4

All values are $\bar{x} \pm$ SD

CHAPTER 5. DISCUSSION

5-1 Subject Characteristics

Pre-training values for $\dot{V}O_2$max for both groups are somewhat below the average for an age-matched general population (Shepherd, 1966) but are comparable to values reported for previously untrained sedentary middle-aged males (Davis *et al*. 1979). Although pre-training values were not significantly different between groups, the SED group had slightly higher values for both absolute ($l.min^{-1}$) and relative ($ml.kg.^{-1}min^{-1}$) measures of VO_2max. This is consistent with the findings of other investigators who report that once athletes cease to train, they experience a rapid decline in $\dot{V}O_2$max to average or below-average values (Dill, 1958: Dill *et al*., 1967; Skinner, 1973: Robinson *et al*., 1976). The fact that pre-training values for both groups were so low is indicative that all subjects had indeed been relatively sedentary for a considerable length of time.

The formerly-active group, in addition to having slightly lower initial fitness levels, was also somewhat heavier (by approximately five kilograms), although the percentages of body fat were almost identical between groups. This weight differential, while once again not significant, is in agreement with the findings of Montoye *et al*., (1962) who reported identical weight differences between former college athletes and non-athletic college alumni.

As a group, subjects exhibited resting blood pressures within normal limits, although slightly higher than the values reported by Fardy *et al*.,(1976). One subject in the SED group had been diagnosed as being hypertensive three years previously and was taking 100 mg. day^{-1} of metoprolol tartrate (a cardio-selective beta-blocker). This subject was able to attain a maximal heart rate of only 158 beats.min.$^{-1}$ due to the effect of the medication. In general, however mean maximal heart rates were very close to those predicted by the equation HRmax = 220-age developed by Karvonen *et al*., (1957). This suggests that subjects worked at maximal or near maximal levels during the tests of maximal aerobic power.

Test-retest reliability for the pre-training $\dot{V}O_2$max tests was very high ($r = 0.96$) for both absolute and relative $\dot{V}O_2$max. A third $\dot{V}O_2$max test was required in two subjects due to equipment malfunction; i.e., the values of the two pre-training $\dot{V}O_2$max tests did not differ by more than five per cent for the remaining subjects.

Pre-training values for the AerT (which was considered to be identical to the AT of Wasserman et al. (1973) and Davis et al., (1976)) are within the range of expected values (40-60% $\dot{V}O_2$max) according to Skinner and McLellan (1980) and are consistant with the findings of other investigators (Ivy et al. 1980; Ivy et al. 1981; Yeh et al. 1983). Relative AerT was not significantly correlated to $\dot{V}O_2$max for either group which is in conflict with Costill (1970) and Costill et al. (1973) who reported significant correlations between these two variables. McLellan and Skinner (1981) hypothesized that strong correlations between relative AerT and $\dot{V}O_2$max may exist only in the upper end of the fitness continuum, however, there is little research available to substantiate this hypothesis. It is possible, that individuals who possess relatively low values for maximal aerobic power are forced to work at a higher percentage of $\dot{V}O_2$max in day-to-day activities thereby creating a stimulus for higher relative AerT. Until more information becomes available however, this remains pure speculation. Factors other than absolute values for $\dot{V}O_2$max must therefore be considered to be confounding variables in the individual variation observed in relative AerT. These were discussed at length in the review and include per cent ST muscle fibre composition, per cent ST muscle fibre area, oxidative enzyme activity and substrate availability and utilization. Since none of these parameters were measured in the present investigation, we can only speculate as to the relative roles each of these factors play in determining individual variation in AerT.

Absolute values for AerT were somewhat lower than those recorded for more fit and younger subjects (Weltman and Katch, 1979; Tesch et al.,1981; Ready and Quinney, 1982; Green et al., 1983) which is to be expected, but were slightly higher than values reported by Davis et al., (1979) for slightly older sedentary males (mean age = 43.0 years) and by Wasserman et al. (1973) for their least fit healthy subjects. Absolute AerT did not differ between groups and was highly correlated to $\dot{V}O_2$max ($l.min^{-1}$) for both the FA ($r = 0.73$) and SED ($r = 0.90$) groups. This strong relationship between these two variables has been documented by other investigators (Weltman and Katch, 1979; Davis et al., 1979). In fact, Weltman and Katch (1979) concluded that $\dot{V}O_2$max could be reliably predicted from absolute AT (equivalent to AerT) determined via gas exchange.

As mentioned previously, the AnT of Skinner and McLellan (1980) has largely been ignored by other investigators although values obtained by Rusko et al., (1980) (85.7% $\dot{V}O_2$max) and Huges et al., (1982) (72.0% $\dot{V}O_2$max) are significantly higher than the 40-60% range commonly accepted for the AT of Wasserman et al. (1973) and Davis et al. (1976). It is possible that these two investigators have unwittingly measured the AnT as defined by Skinner and McLellan (1980) although both studies claim to have employed the criteria developed by Wasserman et al. (1973). Relative AnT determined in the present investigation was within acceptable limits as defined by Skinner and McLellan (1980) (65-90% $\dot{V}O_2$max) for both groups. The same trend that was observed in the relative AerT was repeated for relative AnT, i.e., the SED group had significantly higher values for this parameter. It may be hypothesized that the same explanation that was developed for the AerT observation could be applied to this finding as well. However, day-to-day activities for both groups (having been defined as relatively sedentary) would hardly be of sufficient intensity or be conducted frequently enough to produce alterations in the AnT. It is tempting to speculate that the AerT and AnT are related, i.e. that individuals with high relative values for AerT exhibit the same trend for AnT, however the correlation between these two parameters was not significant in this study (r = 0.49). There is not enough information in the literature and variables measured in the present study provided no insight as to why this difference should exist between these two groups. Absolute values for AnT were not significantly different between groups, and the correlations observed between AnT ($l.min^{-1}$) and $\dot{V}O_2max$ ($l.min^{-1}$) were almost identical ($r = 0.94$ for the FA group; $r = 0.96$ for the SED group).

5-2 Training Effects

There was no significant difference between groups for either relative or absolute $\dot{V}O_2max$ at any time (0, 4 or 8 weeks). However, since the FA group was slightly less fit prior to training (in both $l.min^{-1}$ and $ml.kg.^{-1}min^{-1}$), and slightly more fit at the conclusion of the training program ($l.min^{-1}$), the relative improvement demonstrated by the FA group was greater. Thus, the percentage increase achieved by the FA group was significantly greater than that of the SED group. The average improvement in $\dot{V}O_2max$ (13-21%) is similar to that reported by other investigators for sedentary males following the completion of an eight to ten week endurance training program (Saltin et al., 1969; Pollock et al., 1976; Yoshida et al., 1982). One possible explanation for the difference in relative improvement may lie in the group differences for relative AerT and AnT. The SED group had higher relative values (% $\dot{V}O_2max$) for both AerT and AnT.

Thus, even though training intensities were identical for both groups, the FA group was training at a higher $\dot{V}O_2$ relative to the AerT and was also training closer to their AnT (i.e., during the last four weeks of the training program, the training intensity was established at 75% $\dot{V}O_2$max for both groups which was roughly 3% below the relative AnT determined for the FA group and 8% below the relative AnT for the SED group). Likewise, the 75% training intensity was approximately 25% above the four-week AerT for the FA group but only 20% above the AerT of the SED group. The same trend is apparent over the first four weeks of training. Thus, the training stimulus may have been slightly greater for the FA group than for the SED group despite training at the same relative intensities, which could have resulted in the differential improvement in relative $\dot{V}O_2$max.

The explanation for the difference in improvement may also be partially related to the amount of work completed over the eight weeks. The mean training heart rates were slightly higher for the SED group over the first four weeks of training as was the mean total power output per training session. Due to the relatively larger increase in $\dot{V}O_2$max (i.e. % improvement) from weeks 0-4 for the FA group, this trend was reversed from weeks 4-8, i.e. the FA group trained at a slightly higher HR which is reflected in a greater mean power output per training session. When % increase in $\dot{V}O_2$max was correlated to % increase in mean power output, a moderate relationship emerged (r = 0.73). Thus the difference observed between the two groups may simply be a function of the increase in the amount of work accomplished.

Contrary to what was expected, there was no significant change in relative AerT with training. This is in conflict with the findings of other investigators who observed significant improvements in relative AerT (or AT) with training (Davis et al., 1979; Ready and Quinney, 1982; Yoshida et al., 1982), but is in close agreement with McLellan and Skinner (1981) who reported virtually no change with training. This apparent conflict is probably due to differences in frequency, duration and intensity of training. Subjects in the Davis et al. (1979) and Ready and Quinney (1982) studies trained four times per week at intensities ranging from 75-85% $\dot{V}O_2$max for 9 weeks; i.e., more frequently, at a greater intensity and for a longer duration than subjects in the present investigation. Direct comparison with the Yoshida et al.(1982) data is not possible as the training intensity was based on blood lactate accumulation, not on % $\dot{V}O_2$max. Similarly, increases observed in absolute AerT in this study are significantly less than those reported by Davis et al. (1979), Ready and Quinney (1982) and Yoshida et al. (1982). This is also probably a result of difference in training protocols. Kindermann et al. (1979) suggests that endurance training at lower intensities may be sufficient to result in improvements in the cardio-vascular system thereby improving $\dot{V}O_2$max, but the stimulus may not be adequate enough to promote changes or adaptations at the cellular level which is where reactions governing anaerobic threshold occur.

Thus, in the present investigation, the training intensity was high enough to produce significant increases in $\dot{V}O_2$max but resulted in only relatively small increases in absolute AerT and AnT as compared to other studies employing higher training intensities, and virtually no alteration in relative values for the thresholds.

The increases in absolute AerT and AnT, although not large, were statistically significant for both groups. It has been postulated that the preferential H-LDH isozyme enzyme distribution evolving from endurance training (resulting in a slower rate of pyruvate to lactate conversion) ultimately results in the athlete being able to accomplish more work at a higher intensity before lactate accumulation produces the inhibition of lipid metabolism and a shift to carbohydrate fuel which is characteristic of anaerobic work (i.e., the AerT and AnT are delayed) (Skinner and McLellan, 1980). The percent improvement in absolute AerT and AnT was smaller for the SED group which, once again, is possibly a function of training intensity relative to the AerT and AnT.

Absolute AerT and AnT were strongly correlated to $\dot{V}O_2$max pre- and post-training for both groups. The pre- and post-training relationship of absolute AerT to $\dot{V}O_2$max for the FA group ($r = 0.73$) is in close agreement with the correlation coefficient reported by Davis *et al*. (1979). Similarly, as in the Davis study, training did not alter the relationship. Thus, it would appear that $\dot{V}O_2$max accounts for between 50 and 90 per cent of the variation observed in absolute AerT and AnT. We may only speculate that other factors such as muscle fibre composition, oxidative enzyme activity, substrate availability, etc., account for the remainder of the observed variation.

The decline in body weight and body fat with training is consistent with changes observed by Davis *et al*. (1979) following nine weeks of endurance training.

Although there were no significant difference in attitude (as measured by the MacPherson-Yuhasz questionnaire) toward physical activity between groups at any time, it is interesting to note that out of a possible score of 250 (based on 50 questions and on ordinal scale of one to five, five being the 'best' answer), almost all respondents scored close to 200. The implication of this result is that although almost all subjects had a healthy (or 'good') attitude towards physical activity, the attitude was not transfered into action. Indeed, the most common reason given by both groups for not participating in regular sports or exercise at the present time was laziness. The fact that there was virtually no change in attitude following training may have been a function of the high scores recorded prior to training and/or the monotonous nature of the physical activity involved.

Chapter 6 SUMMARY AND CONCLUSIONS

Two groups of age-matched sedentary males (distinguished only by past athletic participation) were placed on eight-week endurance training programs to assess the effects of training on $\dot{V}O_2max$, AerT and AnT, body weight and composition and attitude toward physical activity.

Prior to training there were no significant differences between groups other than the lower relative thresholds recorded for the FA group. Training resulted in significant increases in $\dot{V}O_2max$ ($l.min^{-1}$ and $ml.kg.^{-1}min^{-1}$) and in absolute AerT for the FA group and absolute AnT for both groups. Relative thresholds were unchanged for either group, the FA group maintaining lower values for relative AerT and AnT throughout the training period.

Body weight and body fat showed small but significant declines for both groups following training.

There was no change in attitude toward physical activity as a result of the training program.

It was concluded that:

1. The formerly-active group did not differ significantly from the sedentary group on any pre-training parameter except relative AerT and AnT. If this finding was corroborated in a larger sample, it would indicate that past athletic participation has no influence on level of fitness if a more sedentary lifestyle is adopted.

2. Past athletic participation does not enhance training gains made in absolute or relative $\dot{V}O_2$max, but does seem to positively influence increases in absolute AerT.

3. The observed difference between groups in percent increase in $\dot{V}O_2$max may be a function of training intensity relative to AerT and AnT and/or possibly a result of greater muscle mass, greater heart and lung volumes in the formerly-active group.

4. Absolute values for both thresholds were strongly correlated to $\dot{V}O_2$max both pre- and post-training, indicating that $\dot{V}O_2$max is responsible for a large amount of the variation observed in absolute thresholds.

RECOMMENDATIONS

It is recommended that:

1. An alternative method to self-reporting be developed to assess past athletic participation and levels of physical activity. Self-reporting often leads to exaggeration which, in turn, weakens the design of the study.

2. A computerized linear regression method of threshold determination be employed to remove subjective variation.

3. Training intensity be increased to 80% of $\dot{V}O_2$max and the training period be lengthened by two weeks to more accurately assess the influence of endurance training on the AerT and AnT.

4. Test protocols for maximal oxygen uptake should employ relatively long work periods (i.e., minimum of 4 minutes per work load) to allow for muscle and blood lactate to equilibrate which would facilitate accuracy in determining the AerT and AnT.

5. More comprehensive measures be undertaken to determine the relative significance of various factors influencing individual variation in aerobic and anaerobic threshold (i.e., % slow twitch muscle fibre composition and area, oxidative enzyme activity, substrate availability).

6. Since substrate availability has been shown to influence the onset of the anaerobic threshold, diet should be controlled prior to the testing sessions (i.e., it is possible that a subject could ingest a high-fat meal prior to testing which would delay the anaerobic threshold).

APPENDIX I: AVERAGE METABOLIC COST OF ACTIVITIES

AVERAGE METABOLIC COST OF ACTIVITIES

Mets	Occupational	Leisure
1.5-2.0	Standing at ease; desk work; driving a car	Flying; motorcycling (pleasure); walking (1 mph)
2.5	Bartending; mechanical work on car; hunting (sitting)	Mowing lawn (riding mower); power boating; shooting; shuffleboard; woodworking; washing car; fishing (from boat, bank or ice); walking (2 mph)
3.0	Janitorial work; light welding; housework (scrubbing, waxing)	Billiards; bowling; canoeing (2 mph); horseshoe pitching; cycling (5 mph); golf (power cart); walking (3 mph)
3.5	Stocking shelves; assembly line (with some lifting)	Horseback riding; iceboating; sailing (handling boat); archery
4.0	Painting; masonry; paper hanging; carrying trays, dishes, etc.; gas station mechanical work	Table tennis; mowing lawn (power mower); golf (no cart); baseball; volleyball; softball; cycling (6.5 mph); canoeing (3 mph); walking (3.5 mph)
5.0	Carpentry, handyman work; carrying 30-50 lbs.	Gardening; lawn work; social dancing; walking (4 mph)
6.0	Pneumatic tools; chopping wood (hand axe or saw); carrying 50-60 lbs.	Cycling (9 mph); fishing (wading in stream); hiking; hunting; water skiing; mowing lawn (push mower); shoveling (10/min, 9 lbs.); square dancing; dancing (rhumba)
7.0	Carrying 60-70 lbs.	Badminton; tobogganing; sledding; scuba diving; walking (5 mph); running (5 mph)
8.0	Carrying 70-90 lbs.	Basketball (non-game); tennis; canoeing (4 mph); cycling (12 mph); swimming (breaststroke, 40 yds./min.)
9.0	-------	Cycling (13 mph); snow skiing; running (6 mph); shoveling (10/min., 14 lbs.); horseback riding (gallop)
10.0	-------	Running (7 mph); swimming (crawl, 50 yds./min or backstroke, 45 yds./min); mountain climbing; squash; fencing; gymnastics
12.0	-------	Handball; shoveling (10/min, 19 lbs.); hockey; soccer; basketball (competition)
13.0	-------	Running (8 mph)
15.0	-------	Running (9 mph)

APPENDIX II: PRESENT OCCUPATIONAL STATUS OF FORMERLY-ACTIVE (FA) AND SEDENTARY (SED) SUBJECTS

Present Occupational Status of Formerly-Active (FA) And Sedentary (SED)

Formerly Active

Subject	Occupation
B.A.	Graduate Student/Waiter
C.B.	University Professor
D.C.	Administrator
B.F.[a]	University Professor
C.F.[b]	Administrator
H.G.	Police Officer
D.H.	University Professor
B.J.	Senior Programmer Analyst
D.J.	University Professor
J.J.	Graduate Student

Sedentary

D.A.	Lawyer
K.D.	Accountant
M.E.	Engineer
M.F.	University Professor
N.F.	Research Technician
D.M.	Data Control Supervisor
F.M.	Lithographer[c]
A.N.	University Professor
V.N.	Radio Newscaster
T.S.	Engineer
D.W.	Sales Tax Clerk

[a] worked two summers in railway construction

[b] worked five summers in a steel mill (sludge removal)

[c] blue-collar occupation

APPENDIX III: ATHLETIC PROFILES OF FORMERLY-ACTIVE SUBJECTS

Athletic Profiles of Formerly-Active Subjects

Subject	Sport(s)	Length of Season (months)	# Practices Week	Length of Practice (hrs.)	Yrs. of Participation
BA	H.S. Basketball	3	3	1.5	4
	H.S. Volleyball	2	3	1.5	4
	H.S. Track (100,200m)	2	4	2	4
CB	Rugby (Club & School)	6	3	2	12
	H.S. Track	2	3	1.5	3
DC	Badminton (H.S. and Club)	5	4	2	3
*BF	Club Swimming	12	5	1	3
	Football (School & Club)	4	4	1.5	5
*CF	Football (H.S. & College)	4.5	4	2.5	8
HG	Wrestling (University)	4	5	2	2
DH	Football (High School)	4	5	2	2
	H.S. Hockey	4	3	1	3
BJ	Tennis (H.S. & Club)	6	3	2	4
DJ	Club Swimming	12	6	2 - 4	7
JJ	Club Soccer	6	3	2	3

*performed heavy manual labour while in college

APPENDIX IV: RELIABILITY AND REPRODUCIBILITY

APPENDIX IV: RELIABILITY AND REPRODUCIBILITY

Reliability and Reproducibility Of The Two Pre-Training Tests For VO_2max And For Intra- And Inter-Observer Determinations Of The Aerobic (AerT) and Anaerobic (AnT) Thresholds

		Test 1.	Test 2.	Reliability Coefficient
$\dot{V}O_2$max	l.min^{-1}	2.82 ± 0.36	2.82 ± 0.33	0.96
	ml.kg.$^{-1}$min^{-1}	33.40 ± 4.94	33.53 ± 4.70	0.96
Intra-Observer				
AerT	l.min^{-1}	1.53 ± 0.24	1.50 ± 0.19	0.71
AnT	l.min^{-1}	2.32 ± 0.30	2.30 ± 0.32	0.86
Inter-Observer				
AerT	l.min^{-1}	1.52 ± 0.22	1.50 ± 0.19	0.78
AnT	l.min^{-1}	2.33 ± 0.39	2.30 ± 0.32	0.92

All values $\bar{x} \pm$ 0.

APPENDIX V: SUMMARY OF CORRELATION COEFFICIENTS

Summary Of Correlations

FA Group	Variables	Correlation Coefficient
Pre-Train	AerT (l.min^{-1} - $\dot{V}O_2$max (l.min^{-1})	0.73
	AerT (% $\dot{V}O_2$max) - $\dot{V}O_2$max (l.min^{-1})	-0.31
	AnT (l.min^{-1} - $\dot{V}O_2$max (l.min^{-1})	0.94
	AnT (% $\dot{V}O_2$max) - $\dot{V}O_2$max (l.min^{-1})	0.26
Post-Train	AerT (l.min^{-1}) - $\dot{V}O_2$max (l.min^{-1})	0.73
	AerT (% VO_2max) - $\dot{V}O_2$max (l.min^{-1})	-0.75
	AnT (l.min^{-1}) - $\dot{V}O_2$max (l.min^{-1})	0.96
	AnT (% $\dot{V}O_2$max) - $\dot{V}O_2$max (l.min^{-1})	-0.13
SED GROUP		
Pre-Train	AerT (l.min^{-1}) - $\dot{V}O_2$max (l.min^{-1})	0.90
	AerT (% $\dot{V}O_2$max) - $\dot{V}O_2$max (l.min^{-1})	-0.16
	AnT (l.min^{-1}) - $\dot{V}O_2$max (l.min^{-1})	0.96
	AnT (% $\dot{V}O_2$max) - $\dot{V}O_2$max (l.min^{-1})	0.07
Post-Train	AerT (l.min^{-1}) - $\dot{V}O_2$max (l.min^{-1})	0.83
	AerT (% $\dot{V}O_2$max) - $\dot{V}O_2$max (l.min^{-1})	0.01
	AnT (l.min^{-1}) - $\dot{V}O_2$max (l.min^{-1})	0.92
	AnT (% $\dot{V}O_2$max) - $\dot{V}O_2$max (l.min^{-1})	-0.33
All Subjects		
	% $\dot{V}O_2$max & Initial $\dot{V}O_2$max	-0.14
	% $\dot{V}O_2$max & Age	-0.26
	% $\dot{V}O_2$max & Total Work	0.73

APPENDIX VI: INDIVIDUAL DATA

Subjects	Age	WT. (kg)			% Body Fat	
		0	4	8	0	8
Sedentary						
1. D.W.	38	73.4	71.1	68.0	24.00	21.72
2. M.F.	37	66.1	64.0	66.1	12.19	11.72
3. V.N.	35	90.2	90.0	88.5	25.00	23.23
4. N.F.	33	77.3	77.3	76.8	22.31	21.50
5. M.E.	35	64.3	64.0	64.2	16.90	16.03
6. F.M.	30	99.3	96.6	95.8	30.00	27.84
7. K.D.	34	119.7	119.9	118.8	28.77	28.16
8. D.A.	35	90.0	88.9	90.9	25.00	21.56
9. T.S.	32	92.8	92.6	93.1	24.84	23.92
10. D.M.	31	83.7	82.6	83.4	24.98	24.02
11. A.N.	35	63.2	63.0	63.1	26.75	24.28
$\bar{x}$	34.1	83.6	82.7	82.6	23.70	22.18
SD	2.0	17.7	17.4	17.1	5.12	4.78
SEM	0.7	5.19	5.25	5.16	1.54	1.44

Subjects	Age	WT. (kg)			% Body Fat	
		0	4	8	0	8
Formerly Active						
1. H.G.	37	103.7	105.8	105.9	30.64	29.11
2. J.J.	34	103.2	99.6	99.7	31.01	28.73
3. D.J.	35	81.1	80.9	80.8	27.03	25.95
4. B.J.	37	77.2	76.1	75.1	19.56	19.03
5. B.A.	32	73.7	71.0	70.3	19.45	14.86
6. D.C.	39	97.8	91.5	92.6	29.62	27.33
7. D.H.	35	85.8	84.9	88.6	23.91	23.78
8. B.F.	32	83.1	81.5	82.8	18.53	20.11
9. C.F.	34	103.8	102.0	104.2	23.38	24.00
10. C.B.	32	81.2	80.7	81.4	24.30	23.43
$\bar{x}$	34.8	89.1	87.4	88.1	24.74	23.63
SD	2.0	11.8	11.7	12.2	4.71	4.54
SEM	0.8	3.73	3.70	3.86	0.471	1.44

Subjects	$\dot{V}O_2$max					
Sedentary	l/min			ml/kg/min		
	0	4	8	0	4	8
1. D.W.	2.875	3.109	3.323	40.057	43.723	48.078
2. M.F.	2.640	2.664	2.722	40.332	41.617	41.561
3. V.N.	3.274	3.433	3.554	35.360	38.140	40.238
4. N.F.	2.663	2.678	3.008	34.269	34.638	39.516
5. M.E.	2.273	2.366	2.587	35.932	36.975	41.384
6. F.M.	2.927	2.337	3.473	29.933	34.539	36.249
7. K.D.	3.234	3.394	3.596	26.985	28.308	30.175
8. D.A.	3.261	3.271	3.459	37.306	37.789	38.921
9. T.S.	3.082	3.047	3.237	33.084	32.908	34.654
10. D.M.	2.892	3.236	3.519	34.557	39.177	42.185
11. A.N.	2.197	2.442	2.696	35.124	38.770	42.547
$\bar{x}$	2.847	2.998	3.198	34.813	36.871	39.592
SD	0.374	0.391	0.379	3.928	4.237	4.687
SEM	0.113	0.118	0.114	1.184	1.278	1.413

Subjects	$\dot{V}O_2max$					
Formerly Active	1/min			ml/kg/min		
	0	4	8	0	4	8
1. H.G.	2.841	2.820	2.944	26.977	26.658	27.795
2. J.J.	2.806	2.887	3.173	27.713	28.983	31.633
3. D.J	2.886	2.891	3.025	35.343	35.740	37.395
4. B.J.	2.372	2.592	2.771	30.985	34.050	36.866
5. B.A.	2.481	2.786	2.911	34.548	39.235	41.632
6. D.C.	2.622	2.834	3.027	27.717	30.968	32.471
7. D.H.	3.196	4.006	4.476	37.023	47.181	50.432
8. B.F.	3.293	3.847	3.882	40.208	47.200	47.936
9. C.F.	2.430	3.439	3.316	23.641	33.713	32.333
10. C.B.	2.924	3.856	3.975	36.175	47.777	49.157
$\bar{x}$	2.785	3.196	3.350	32.033	37.151	38.765
SD	0.312	0.534	0.565	5.38	7.869	8.125
SEM	0.099	0.169	0.179	1.70	2.488	2.569

Individual Data: % ↑ $\dot{V}O_2$max (1/min)(ml.kg^{-1}min^{-1})

Subjects	l.min^{-1}			ml.kg^{-1}min^{-1}		
	Weeks			Weeks		
SED	**0-4**	**4-8**	**0-8**	**0-4**	**4-8**	**0-8**
1. D.W.	8.14	6.89	15.58	9.15	9.96	20.02
2. M.F.	0.91	2.18	3.12	3.19	0	3.06
3. V.N.	4.86	3.52	8.55	7.86	5.50	13.80
4. N.F.	0.06	12.32	12.96	1.08	14.08	15.02
5. M.E.	4.09	9.34	13.81	2.90	11.92	15.17
6. F.M.	14.01	4.07	18.65	15.39	4.95	21.10
7. K.D.	4.95	5.95	11.19	4.90	6.60	11.82
8. D.A.	0.03	5.75	6.07	0	5.80	4.33
9. T.S.	0	6.24	5.03	0	5.31	4.75
10. D.M.	11.89	8.75	21.68	13.37	7.68	22.07
11. A.N.	11.15	10.40	22.71	10.38	9.74	21.13
$\bar{x}$	5.463	6.855	12.668	6.202	7.41	13.843
SD	5.154	3.088	6.632	5.381	3.861	7.129
SEM	1.554	0.931	2.000	1.622	1.164	2.149

Individual Data: % ↑ $\dot{V}O_2$max (l/min)(ml.kg^{-1}min^{-1})

Subjects	l.min^{-1}			ml.kg^{-1}min^{-1}		
	Weeks			Weeks		
F.A.	0-4	4-8	0-8	0-4	4-8	0-8
1. H.G.	0	4.40	3.63	0	4.27	3.03
2. J.J.	2.89	9.91	13.08	4.58	9.14	14.14
3. D.J.	0.17	4.64	4.82	1.12	4.63	5.81
4. B.J.	9.27	6.91	16.82	9.89	8.27	18.98
5. B.A.	12.29	4.49	17.33	13.57	6.11	20.50
6. D.C.	8.09	6.81	15.45	11.73	4.85	17.15
7. D.H.	25.34	11.73	40.05	27.44	6.89	36.22
8. B.F.	16.82	0.91	17.89	17.39	1.56	19.22
9. C.F.	41.52	0	36.46	42.60	0	36.77
10. C.B.	31.87	3.09	35.94	32.07	2.89	35.89
$\bar{x}$	14.826	5.289	20.147	16.039	4.861	20.771
SD	14.053	3.676	12.976	14.01	2.875	12.132
SEM	(4.44)	(1.16)	(4.10)	(4.43)	(0.91)	(3.84)

Subjects	MacPherson-Yuhasz	
F.A.	Pre	Post
1. H.G.	189	195
2. J.J.	215	183
3. D.J.	203	200
4. B.J.	178	188
5. B.A.	203	206
6. D.C.	186	183
7. D.H.	192	201
8. B.F.	198	193
9. C.F.	188	193
10. C.B.	183	185
$\bar{x}$	193.5	192.7
SD	11.2	8.0
SEM	3.54	2.53
SED		
1. D.W.	215	201
2. M.F.	224	222
3. V.N.	199	195
4. N.F.	171	175
5. M.E.	192	193
6. F.M.	188	191
7. K.D.	195	187
8. D.A.	178	181
9. T.S.	186	184
10. D.M.	179	187
11. A.N.	214	218
$\bar{x}$	194.6	194.0
SD	17.0	14.7
SEM	5.13	4.43

THRESHOLD DATA

Subjects	AerT (l/min) (% max)		
	0	4	8
F.A.			
1. H.G.	1.575 (55.44)	1.780 (63.12)	1.715 (58.25)
2. J.J.	1.380 (49.18)	1.460 (50.57)	1.715 (54.05)
3. D.J.	1.595 (55.27)	1.580 (54.65)	1.775 (58.68)
4. B.J.	1.245 (52.49)	1.410 (54.40)	1.525 (55.03)
5. B.A.	1.160 (46.75)	1.390 (49.89)	1.325 (45.52)
6. D.C.	1.510 (57.59)	1.560 (55.05)	1,565 (51.70)
7. D.H.	1.540 (48.19)	1.670 (41.69)	1.945 (43.45)
8. B.F.	1.515 (46.01)	1.910 (49.65)	1.645 (42.38)
9. C.F.	1.215 (50.00)	1.300 (47.80)	1.590 (47.95)
10. C.B.	1.380 (46.91)	1.630 (42.27)	1.605 (40.38)
$\bar{x}$	1.412 (50.78)	1.569 (50.91)	1.641 (49.74)
SD	0.159 (4.15)	0.188 (6.36)	0.027 (6.21)
SEM	0.050 (1.31)	0.059 (2.01)	0.009 (2.12)
SED			
1. D.W.	1.505 (52.35)	1.640 (52.75)	1.725 (51.91)
2. M.F.	1.510 (57.20)	1.610 (60.44)	1.515 (55.66)
3. V.N.	1.895 (57.88)	1.930 (56.22)	2.095 (58.95)
4. N.F.	1.570 (58.96)	1.630 (60.86)	1.575 (52.36)
5. M.E.	1.415 (62.25)	1.340 (56.64)	1.295 (50.06)
6. F.M.	1.735 (59.28)	1.680 (50.34)	1.745 (50.24)
7. K.D.	1.690 (52.26)	1.710 (50.38)	1.745 (48.53)
8. D.A.	1.675 (51.36)	1.800 (55.03)	1.795 (51.89)
9. T.S.	1.730 (56.13)	1.810 (59.40)	1.815 (56.07)

Subjects	AerT (l/min) (% max)		
	0	4	8
SED			
10. D.M.	1.560 (53.94)	1.750 (54.08)	1.710 (48.59)
11. A.N.	1.295 (58.94)	1.250 (51.19)	1.340 (49.70)
$\bar{x}$	1.598 (56.41)	1.650 (55.21)	1.669 (52.18)
SD	0.168 (3.51)	0.200 (3.88)	0.227 (3.37)
SEM	0.051 (1.06)	0.060 (1.17)	0.068 (1.02)

THRESHOLD DATA

Subjects	AnT (l/min) (% max)		
	0	4	8
F.A.			
1. H.G.	2.360 (83.07)	2.420 (85.82)	2.485 (84.41)
2. J.J.	2.265 (80.72)	2.220 (76.90)	2.655 (83.67)
3. D.J.	2.475 (85.76)	2.460 (85.09)	2.360 (78.02)
4. B.J.	2.005 (84.53)	1.900 (73.30)	2.310 (83.36)
5. B.A.	1.775 (71.54)	2.060 (73.94)	2.190 (75.23)
6. D.C.	2.070 (78.95)	2.420 (85.39)	2.520 (83.25)
7. D.H.	2.610 (81.66)	2.990 (74.64)	3.275 (73.17)
8. B.F.	2.690 (81.69)	3.080 (80.06)	2.950 (75.99)
9. C.F.	1.810 (74.49)	2.180 (73.39)	2.535 (76.45)
10. C.B.	2.075 (70.96)	2.960 (76.76)	2.990 (75.22)
$\bar{x}$	2.214 (79.34)	2.469 (78.53)	2.627 (78.88)
SD	0.319 (5.27)	0.412 (5.18)	0.343 (4.31)
SEM	0.101 (1.67)	0.130 (1.64)	0.109 (1.36)
SED			
1. D.W.	2.390 (83.13)	2.520 (81.06)	2.680 (80.65)
2. M.F.	2.240 (84.85)	2.330 (87.46)	2.475 (90.93)
3. V.N.	2.665 (81.40)	2.990 (87.10)	3.155 (88.77)
4. N.F.	2.360 (88.62)	2.250 (84.02)	2.410 (80.12)
5. M.E.	1.970 (86.67)	2.080 (87.91)	2.270 (87.75)
6. F.M.	2.570 (87.80)	2.720 (81.51)	2.870 (82.64)
7. K.D.	2.685 (83.02)	2.770 (81.62)	2.785 (77.45)
8. D.A.	2.855 (87.55)	2.790 (85.30)	2.840 (82.10)
9. T.S.	2.520 (81.77)	2.500 (82.05)	2.765 (85.42)

Subjects	AnT (1/min) (% max)		
	0	4	8
SED			
10. D.M.	2.475 (85.58)	2.530 (78.18)	2.810 (79.85)
11. A.N.	1.635 (74.42)	1.990 (81.49)	2.285 (84.76)
$\bar{x}$	2.397 (84.07)	2.497 (83.43)	2.668 (83.68)
SD	0.347 (4.05)	0.312 (3.15)	0.276 (4.22)
SEM	0.105 (1.22)	0.094 (0.95)	0.083 (1.27)

APPENDIX VII: MacPHERSON-YUHASZ ATTITUDE TOWARD EXERCISE AND PHYSICAL ACTIVITY QUESTIONNAIRE

MacPHERSON-YUHASZ ATTITUDE TO EXERCISE AND PHYSICAL ACTIVITY QUESTIONNAIRE

1. Physical exercise is beneficial to the human body.
2. Exercise helps to work off emotional tensions and anxieties.
3. Adults get all the physical activity they need in their daily work.
4. Exercise is of little value in maintaining desirable body weight.
5. Regular physical activity makes one feel better.
6. Physical education should be a required subject for elementary and secondary school children.
7. Exercise does more harm than good.
8. Those who are physically able should take part in a daily period of physical activity.
9. An individual has all the strength and stamina he needs without participating in a programme of exercise.
10. Exercise does little to improve a person's sense of well-being.
11. Heavy physical exercise makes an individual muscle bound.
12. When recovering from a cold it is best if one does not engage in physical activity.
13. Participation in physical activity aids mental relaxation.
14. Exercise is important in aiding a person to gain and maintain all-round good health.
15. The heart cannot be strengthened by exercise.
16. A person's leisure time should be spent in rest and relaxation.
17. Individual sports such as tennis are more satisfying to play than team games.
18. I think exercise is good for me.
19. You should seek help from a qualified physical educator before you undertake strenuous exercise.
20. Regular exercise decreases one's desire to smoke.
21. A person in good physical condition is better able to endure nervous stress.
22. Exercising with a group leads to improved social relationships.
23. Exercise becomes less necessary as one advances in age.
24. A woman can improve her poise and posture by regular participation in physical activity.
25. Regular physical acitivity has a beneficial effect on an individual's ability to carry out his job responsibilities.

26. Exercise gets rid of harmful feelings and emotions such as anger and hostility.
27. Those who are physically healthy do not need to engage in physical exercise.
28. Anyone over 25 years of age should avoid exercise because he might strain his heart.
29. Regular participation in physical activity makes one look better.
30. It is better to have never exercised at all than to have exercised and stopped completely.
31. It is annoying that we have to waste our time exercising.
32. A period of exercise gives a lasting feeling of well-being.
33. Exercise is of no real value in improving one's health.
34. Those who are physically able should engage in a weekly session of physical activity.
35. Muscles, when not used, turn to fat.
36. Exercise is valuable in building up an adequate reserve of strength and stamina for everyday living.
37. Regular exercise does not relieve constipation.
38. If I exercised I would rather do it by myself.
39. Girls should not exercise strenuously because they will become muscular.
40. Physical exercise is less important today than it was in my parent's time.
41. Exercise increases one's appetite.
42. When one reaches full physical growth exercise is no longer necessary.
43. Physical activity in some form is an excellent remedy for the tense irritable and anxious person.
44. Regular physical activity makes a man more alert.
45. Regular physical activity has little effect on one's personality.
46. A person in good physical condition is less likely to have colds.
47. Regular physical activity will help me live longer.
48. Working up a good sweat helps to get rid of body poisons.
49. When a person improves his physical condition he improves his work productivity.
50. Physical activity can help in preventing major medical diseases.

APPENDIX VIII: REASONS GIVEN FOR NEVER PARTICIPATING OR CEASING TO PARTICIPATE IN SPORTS OR PHYSICAL ACTIVITY

Reasons Given For Never Participating or For Ceasing To Participate In Sports or Physical Activity

Formerly-Active Subjects

Subject	Reason
BA	Lack of time
CB	Laziness
DC	Laziness
BF	Lack of facilities/laziness
CF	Lack of facilities
HG	Poor physical condition/lack of a companion
DH	Lack of time
BJ	Poor physical condition/fear of exertion
DJ	No reason given
JJ	Lack of time/no companion

Sedentary Subjects

Subject	Reason
DA	Laziness/lack of self-confidence
KD	Lack of time
ME	Lack of opportunity/facilities
MF	Laziness
NF	Laziness
DM	Lack of time
FM	Poor physical condition/lack of time
AN	Lack of time
VN	Lack of opportunity/laziness
TS	Lack of opportunity
DW	Too old

Reasons Given For Never Participating or For Ceasing To Participate In Sports or Physical Activity

Formerly-Active Subjects

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BA	Lack of time
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Sedentary Subjects

Subject	Reason
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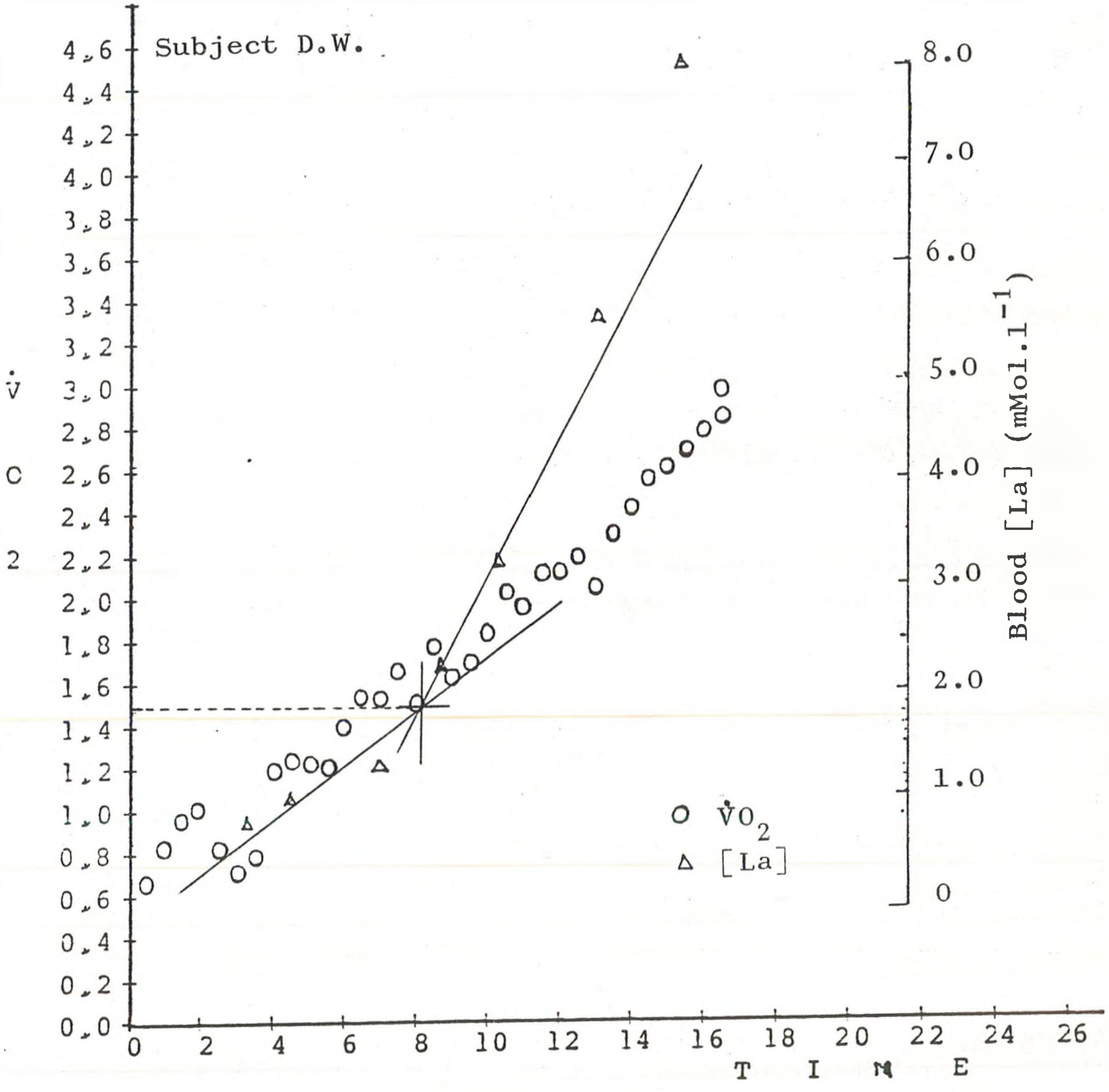
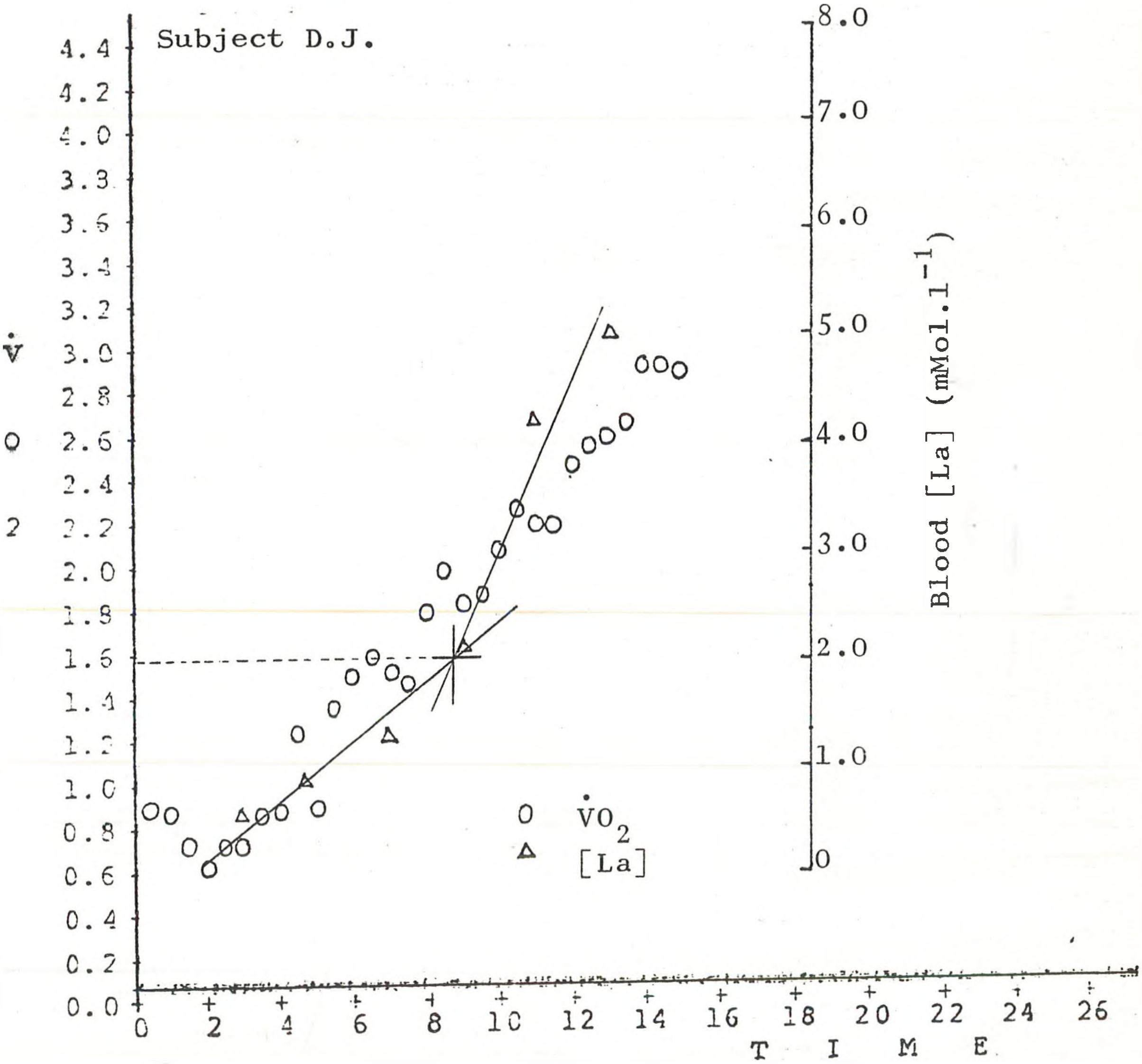
FM	Poor physical condition/lack of time
AN	Lack of time
VN	Lack of opportunity/laziness
TS	Lack of opportunity
DW	Too old

APPENDIX IX LACTATE DETERMINATIONS OF AerT IN TWO SUBJECTS



Blood Lactate Determination of AerT



Blood Lactate Dertmination of AerT

APPENDIX X

GLOSSARY OF TERMS

anaerobic threshold (AT) - the level of oxygen consumption where anaerobic metabolism begins (Wasserman et al., 1973). This is identical to the aerobic threshold (AerT) of Skinner and McLellan (1980).

anaerobic threshold (AnT) - defined by Skinner and McLellan (1980) (see text).

CS - citrate systhase; an oxidative enzyme

$l.min^{-1}$ - litres per minute

MET - the metabolic equivalent for the expression of oxygen consumption. One MET equals the amount of oxygen consumed at rest and is approximately equal to 3.5 $ml.kg^{-1}.min^{-1}$.

$ml.kg^{-1}.min^{-1}$ - millilitres per kilogram per minute.

SDH - succinate dehydroginase; an oxidative enzyme

ST - slow twitch muscle fibre; muscle fibres that exhibit high myoglobin and mitochondrial content, high oxidative enzyme levels, low glycogen and phospho-crentine content and low glycolytic enzymes.

$\dot{V}O_2$ - oxygen consumption; the total volume of oxygen consumed by the body per unit of time.

$\dot{V}CO_2$ - carbon dioxide production; the total volume of carbon dioxide expired per unit of time.

APPENDIX XI

STATISTICAL ANALYSIS

Variable	df	SS	MS	F RATIO	LEVEL OF SIGNIFICANCE
AnT (% max)					
A	(1,19)	.36378262	.36378262	.11188067	0.003
B	(2,38)	.55537365	.27768683	.21907951	0.804
A x B	(2,38)	.69568947	.34784473	.27443020	0.997
Body wt. (kg.)					
A	(1,19)	.42640130	.42640130	.63842151	0.434
B	(2,38)	.18492381	.92461905	.55125710	0.008
A x B	(2,38)	.22905281	.11452641	.68280547	0.511
% Body Fat					
A	(1,19)	.37992961	.37992961	.87176975	0.362
B	(1,19)	.42624857	.42624857	.51652953	0.035
A x B	(1,19)	.21343052	.21343052	.25863586	0.124
Attitude					
A	(1,19)	.15546320	.15546320	.50353976	0.825
B	(1,19)	.53571429	.53571429	.11903749	0.734
A x B	(1,19)	.70129870	.70129870	.15583090	0.969

Variable	df	SS	MS	F RATIO	LEVEL OF SIGNIFICANCE
$\dot{V}O_2$max (l.min^{-1})					
A	(1.19)	.15552798	.15552798	.31046028	0.584
B	(2,38)	.21580984	.10790492	.35107838	0.000
A x B	(2,38)	.20702765	.10351382	.33679155	0.045
$\dot{V}O_2$max (ml.kg.$^{-1}$min^{-1})					
A	(1,19)	.19352058	.19352058	.20334099	0.657
B	(2,38)	.34726983	.17363491	.42504943	0.000
A x B	(2,38)	.24913051	.12456526	.30492941	0.059
AerT (l.min^{-1})					
A	(1,19)	.15260468	.15260468	.16743873	0.211
B	(2,38)	.23806667	.11903333	.17436238	0.000
A x B	(2,38)	.68782424	.34391212	.50376928	0.011
AerT (% $\dot{V}O_2$max)					
A	(1,19)	.26728626	.26728626	.51174270	0.036
B	(2,38)	.86139165	.43069583	.51149276	0.011
A x B	(2,38)	.26926645	.13463322	.15988992	0.215
AnT (l.min^{-1})					
A	(1,19)	.11120023	.11120023	.37927556	0.545
B	(2,38)	.12037175	.60185873	.26134950	0.000
A x B	(2,38)	.77384964	.38692482	.16801719	0.200

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